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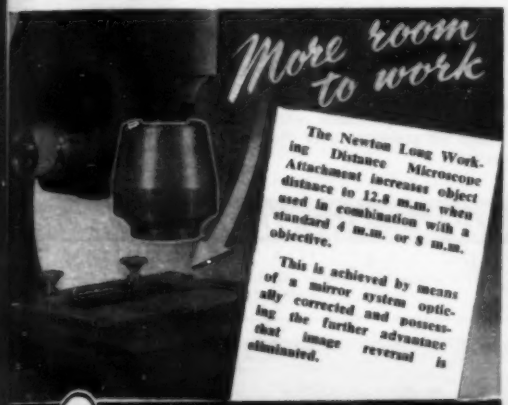
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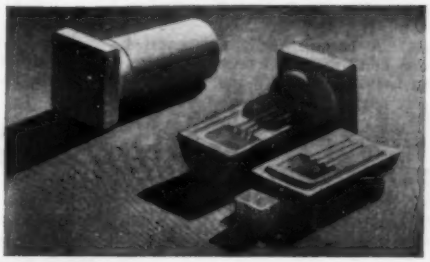

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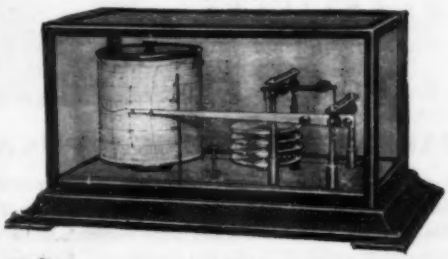

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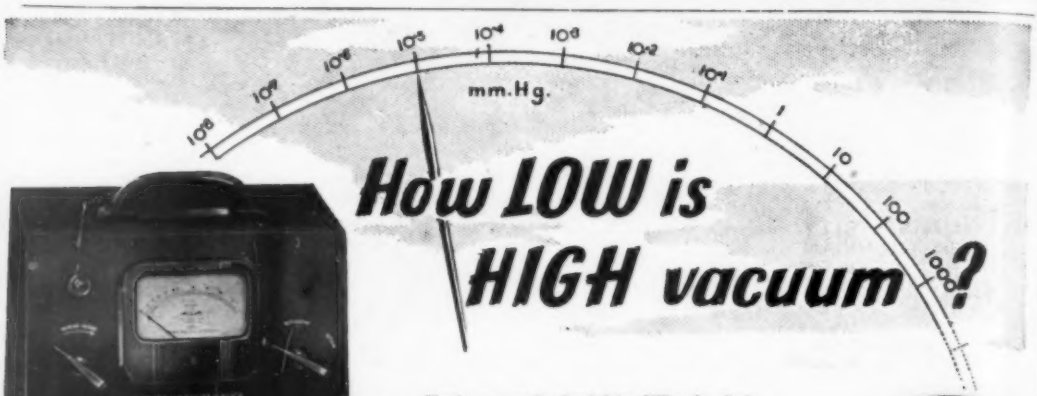

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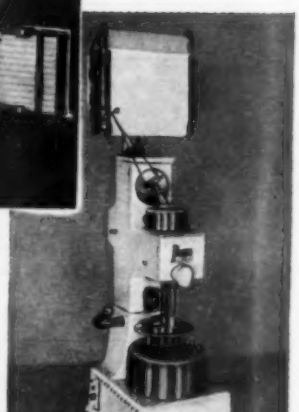

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TEACHING OF GENERAL SCIENCE

IT is of fundamental importance to national and social needs, in an environment which is changing rapidly, that the aims and contents of the science courses in school should be constantly under review. The urgencies of the present make such considerations particularly necessary. In Britain, the supply of adequately equipped science teachers does not keep pace with the demand ; the need for a knowledge of science as a part of the equipment of citizenship, and the requirements of a scientific age for trained workers to sustain it and continue its progress, have never been greater. Again, the General Certificate of Education, which replaces the older school certificate and higher school certificate, should give opportunities in the grammar schools for broader cultural treatments of a number of subjects, and permit the teaching of 'background science' on both the arts and science sides. It is too early yet to say what will be the effect of the new Certificate : so far as science is concerned, it may be a case of *plus ça change, plus c'est la même chose*. An early secondary effect which will need the Minister's attention is the withdrawal, before they have completed the course, of as many as 25 per cent of the pupils at some grammar schools. This is a terrible wastage of potential scientific workers which probably more than offsets the effect of the wider intake resulting from the methods of grammar school selection in force since the 1944 Education Act.

Modern psychological investigations into the contents of education have gone far to modify the old ideas concerning the transfer of training or the disciplinary values of a subject. It is no longer possible to defend a narrow curriculum by urging the claim that it "trains boys to think and to appreciate scientific method". It is doubtless true that a concentrated course in chemistry, for example, may teach a boy to use chemical concepts efficiently ; but it is not worth great expenditure of time and money to train, as budding chemists, boys who will not become chemists. They will not necessarily become better scientific men, still less better citizens.

The publication of a revised edition of "The Teaching of General Science"*, a report by the General Science Sub-committee of the Science Masters' Association, improved by experience gained from a former interim report, is to be welcomed. In ordinary life, opportunities for using scientific knowledge are rapidly increasing in number, and a knowledge of biology can help towards more rational and healthy living. It is impossible, of course, to know what scientific knowledge will be found vocationally useful in twenty-five years, and a broader, more elastic view of science in both school and university is more than ever a necessity. The guiding principles determining the nature of the syllabus given in the report may be summarized as follows : (*a*) the importance of a broadly conceived

* Report on the Teaching of General Science. Prepared by the General Science Sub-Committee of the Science Masters' Association. Pp. vii+128. (London : John Murray, 1950.) 6*s*.

course touching ordinary life at many points; and (*b*) the great importance of stressing scientific principles of wide generality, for when these are thoroughly understood their useful application may easily be extended.

The new syllabus is a great improvement on the old, which at times asked far too much from some of the younger grammar school pupils of average ability. The early training in accurate measurement for its own sake, as a sort of disembodied spirit of experimental science, has given place to a more rational treatment of measurement taught when its need is realized and its nature understood. (Actually, more thought and work along these lines could be done in university courses, for the real nature and meaning of measurement as required in various sciences is little understood by most students.)

The report makes an appeal for the historical method of teaching as being sound pedagogy, and in its suggestions for practical work it strikes a happy medium between the old unrealistic 'heuristic' methods, so wasteful of time, and the slavish following of instructions for carrying out experiments with the foreknowledge of results. All science teachers should want to evolve their own syllabuses to suit their own interests and the needs and environments of their pupils; but the new syllabus will be a useful guide and will serve to show how theoretical and practical work can be linked together at each stage. At last chemistry and biology are given a proper share of the syllabus, and at each stage an experienced science teacher should be able to lead the class to appreciate the scientific method revealed in each topic.

The report, which thinks in terms of a five-year period in the grammar school, does not deal with the requirements of universities in respect of sixth-form pupils. Inevitably a greater degree of specialization will take place here; but the need for a broad background of science is just as important. Much more discussion between universities and schools in Great Britain with regard to science courses is required. University requirements differ, and the extent of the overlap between sixth-form science and first-year university work is difficult to defir Some universities do not recognize biology as a subject, and again some schools do not realize that many professors of botany and zoology, treating their subjects with increasing physiological bias, require a high standard of proficiency in chemistry, before admitting students to their departments.

The difficulties of a reasonable synthesis in science become greater as more is discovered, and a neo-Thomist is bewildered in the face of genetics, mycology, electronics, rheology and new sciences which are developed as separate 'subjects' every year. But this in itself is a strong reason for a broader, integrated conception of science at an earlier stage. "General Science is therefore a course of science which is 'pupil-centred' and does not exclude any of the fundamental sciences. It seeks to elucidate the general principles observable in nature, without emphasising the traditional division into specialised subjects, until such time as this is warranted by the increasing complexity of the field of investigation, by the developing unity of the separate parts of that field and by the intellectual progress of the pupils."

The report under discussion should prove to be a timely corrective to two undesirable tendencies which have appeared in science-teaching in recent years. The first may be summarized by saying, "It does not much matter what you teach as long as you teach scientific method". But scientific method cannot be taught in the abstract, and science teaching should not have a monopoly of the use of scientific method. The second fallacious idea which has troubled the teaching of general science is the imagined need for "a minimum number of '*facts*' of science which should be known by all boys and girls leaving school". This is equally perverse, for we cannot divorce aims and content in education. We should not separate methods and results, and we must be prepared to realize that one of the chief values of science is that it is progressive and adaptable and that the so-called 'facts' and 'laws' of yesterday may appear in a different light when to-morrow dawns.

It remains to be said that the report contains suggestions for an extended syllabus for use in those schools which are able to devote more time to science than that required for the basic syllabus, and a scheme for those who do not specialize in science, which makes reference to the history and methods of science and is related to the development of civilized man, his needs and his environment. The penultimate section of the work is an enlightened short statement of the principles which should underlie examinations in science. Too often in the past a diligent perusal of a single 'tailor-made' text-book and the working of a few stock experiments were sufficient preparation for a stereotyped examination in a science subject, even up to intermediate degree standard. The aims, nature and technique of science examinations and other methods of assessment as tests of ability, aptitude and knowledge are worthy of further consideration on the lines laid down in the report.

HIGHER TECHNOLOGICAL EDUCATION

SPEAKING on technological education on January 10, 1951, at a dinner given by Sir Frederick Handley Page to the Masters and Clerks of the City Livery Companies, to meet the Lord Mayor and Sheriffs and the Council of the City and Guilds of London Institute, Sir Ewart Smith referred to the prominent part played by the City of London and its Livery Companies and Guilds in the development of technical education. He also pointed out that, while Great Britain still leads the world in the field of pure science, that can no longer be said of the whole industrial field. This he attributed mainly to our failure to provide for the education of a sufficient number of our people in applied science. We have to face the need for training a growing number of our population in technology of all kinds, and in urging this Sir Ewart

had also in mind, as a consequence, the injection of more of the critical and analytical approach into all walks of our national life. Technological education should include not only training in fundamentals, or that students are taught to think for themselves, but also a broad basis such as English, history and the elements of economics. The future leaders in the technical field require not only a good knowledge of applied science but also a proper appreciation of the humanities. Similarly, those trained for work in other walks of life such as Parliament, the Civil Service and the local authorities should have a proper general knowledge of science and of the technological approach.

Some of Sir Ewart's points, notably as regards the content of education, were reflected in the debate on higher technological education in the House of Lords on February 1, when the recent report of the National Advisory Council on Education for Industry and Commerce was severely criticized. Opinion was generally expressed that the proposals were likely to do more harm than good, and Viscount Caldecote, in opening the debate, flatly challenged the Ministry of Education with attempting to force the proposals through in defiance of adverse professional opinion. Lord Burden, in his reply, denied that this was so, but was unable to make a definite statement of the Government's policy; nor did he himself distinguish sufficiently clearly between technical and technological education. His remarks certainly gave no reassurance that due care will be taken to see that there is no disturbance of the primary function of technical colleges, namely, to supply industry with the larger numbers of technicians which are also required. In spite of the general condemnation of the proposed institution of a new award and a Royal College of Technology, and disregarding Viscount Caldecote's suggestion that certain technical colleges selected for upwarding to technological institutions of university rank might be styled royal colleges of technology, with appropriate postgraduate diplomas, he clung to the Advisory Council's recommendation. Nor did his reply indicate any real appreciation of the fundamental issue involved in the administration of the colleges of technology if they are to be appropriately staffed and financed for higher technological work. This last point was strongly pressed by Lord Cherwell, following some pertinent remarks about the relative prestige of technological and university education.

Viscount Falmouth paid tribute to the City and Guilds of London Institute as the type of institution that is exactly what is needed, and said that the proposed Royal College of Technology would inevitably make further serious and unprofitable demands for committee and like work in its administration on the time of professors and teachers in existing institutions. Lord Chorley, while agreeing that the technical colleges would require much larger financial resources if they are to train technologists, gave clear warning of the danger of dispersing resources and expensive equipment all over the country to satisfy local interest or vanity, instead of concentrating it in the great technological departments at the universities or in new technological institutes. These points were virtually ignored by Lord Burden, who appeared to be more concerned about the desirability of providing opportunities for a promising technician anywhere to qualify further as a technologist.

Since the debate, the Burnham Technical Committee has proposed new scales of salaries for technical colleges which, if applied, will put heads of departments near the level of the university professor. The discretionary power to decide how to grade such technical staff remains with the local authorities, and accordingly the new award does nothing to remove the substance of the criticism on this point both in the Percy report in 1945 or in the House of Lords debate. The new scales will be adequate for the purpose only if they are administered generously, and there is nothing to suggest that present wide variations in this respect between different authorities will be diminished.

This, of course, is precisely why professional bodies in their comments on the report of the Advisory Council have expressed the view that the vital need is to give direct encouragement to the technical colleges to improve their accommodation, equipment and the conditions of service of their staffs. The Council of the Royal Institute of Chemistry, for example, considers that the most important contribution that can be made to the improvement and development of technological education in Great Britain is to raise the standard of work in the technical colleges. It urges that status as well as remuneration of staff in technical colleges need to be comparable with those in universities in order to secure teachers of eminence in their fields, and it suggests the establishment of a Technology Grants Committee empowered to allocate grants from central funds direct to selected colleges instead of through local channels, so as to give those colleges not only much larger funds but also a degree of academic freedom comparable with that enjoyed by the universities. To help foster the newer technologists and co-ordinate the standards of the relevant courses, it further suggests the establishment of a joint council of professional institutions, with due representation of the universities and colleges of technology.

It is clear that there is still a sharp division of opinion on this subject, which is so vital to the material prosperity of Great Britain, and that the issue is by no means yet decided.

THE MUSE OF SCIENTIFIC RESEARCH

The Art of Scientific Investigation

By Prof. W. I. B. Beveridge. Pp. xii+172+4 plates. (London: William Heinemann, Ltd., 1950.) 10*s.* 6*d.* net.

I WAS much intrigued with the title of this book. Here perhaps was an author to remind us that scientific research, no matter how regimented and misused, is essentially a creative art. Here perhaps was a timely warning that the stupendous endowment and the intricate machinery of modern research

increase, rather than decrease, the importance of the human element. Here perhaps was a book about the psyche of discovery rather than the technology of investigation. I turned to read with the keenest anticipation and I was not disappointed. In writing this book, Prof. W. I. B. Beveridge clearly had in mind investigations leading to major discoveries; he has little to say about the technical researches concerned with 'mopping-up' in the wake of discovery, or about the ponderous quantitative investigations into which much research sooner or later degenerates.

Prof. Beveridge's approach to his theme is mainly analytical. He analyses the circumstances attending discoveries, and the mental characteristics of the men of science responsible. The dissection is done under such headings as chance, hypothesis, imagination, intuition, reason and observation. The last two chapters are devoted to the strategy of research, and to some general remarks about men of science. The book is somewhat repetitious and is written in a matter-of-fact and not always very polished style; but the theme provides all the impetus and colour necessary. The author has a knack of putting into words what most experimenters sooner or later come to realize in a dim way, and it is extraordinarily interesting to see so much of the lore of research set down in print.

Prof. Beveridge follows earlier writers such as Wilfred Trotter in maintaining that, to perceptive minds, chance and intuition are weapons far more potent than reason and logic. As he says, many discoveries could not have been deduced from existing knowledge and could not, therefore, have been arrived at by processes of reason. Few will disagree with this thesis. It is true that to reach the ranks of the immortals a man of science must combine exceptional inspiration with the most precise intellectual machinery; but the fact remains that many scientific workers become prominent mainly by virtue of characteristics other than a capacity for reasoning. The significant conclusion follows that a distinguished man of science may be as irrational as anyone else, or more so.

The book abounds in well-chosen quotations; but Prof. Beveridge's own text will provide quotations as numerous and as pregnant as any of those from other sources. It is difficult to select from such a wealth of material, but the following are chosen at random: "The great scientist must be regarded as a creative artist and it is quite false to think of the scientist as a man who merely follows rules of logic and experiment"; "Research can be planned but discovery cannot"; "How to distinguish the promising clues is the very essence of the art of research"; "The use of statistics does not lessen the necessity for using common sense . . ."; "Discoverers are often men with little experience or skill in human relations . . ."; "Three very important adverse influences have already been mentioned; interruption, worry and competing interests"; "Free discussion requires an atmosphere unembarrassed by any suggestion of authority or even respect"; ". . . an hypothesis is sometimes very fruitful without being correct"; "In applied research it is the project which is given support, whereas in pure research it is the man"; "Descartes is said to have made his discoveries while lying in bed in the morning. . . .".

Of passages too long to quote, one of special interest gives advice to middle-aged research workers to change their line of work before they become sterilized by ossified experience and mummified ideas. In a different way, the analogy of modern research with Columbus's discovery of America is a little masterpiece.

Of the quotations from other authors, two remain in the mind: Trotter's ". . . a new idea is the most quickly acting antigen known to science" is deplorably true; and Shaw's "Reading rots the mind" is a courageous inclusion by an author who has obviously read profoundly.

This book gives the analytical data for the great man of science. Is it thence possible to arrive at the constitutional formula, and perhaps to effect a partial synthesis from more plentiful material? One may well have doubts on this point, but Prof. Beveridge says confidently, and probably rightly, "The rare genius with a flair for research will not benefit from instruction in the methods of research, but most would-be research workers are not geniuses, and some guidance . . . should help them to become productive earlier than they would . . . by the wasteful method of personal experience". For such guidance the research worker—of whatever vintage—cannot do better than read this book, and, having read it, read it again.

A. S. Parkes

THE ANDEAN FLORA

Plant Hunters in the Andes

By T. Harper Goodspeed. Pp. xiv+429+67 plates. (London: Robert Hale, Ltd., n.d.) 21*s.* net.

Dr. T. H. Goodspeed and his colleagues explored the Andean region from Peru to Chile, primarily in search of species of tobacco, and we read in these pages of the adventures which the University of California Botanical Garden Expeditions experienced during 1935–36 and again during 1938–39. The rediscovery of *Nicotiana cordifolia* on the fifth attempt bears witness to the pertinacity of their endeavours.

Many interesting species find mention in these pages. At one time, in the jungle the author is enthusing over the exciting find of hundreds of *Eucharis* with a large white flower and a green throat, and the masses of golden calceolarias; at another, he describes the home of that lightest of woods the balsa tree (*Ochroma*)—used, as its name implies, for rafts—the stems of which can attain a diameter of eighteen inches in five years of growth. *Alstromeria violacea* claims the author's enthusiasm as perhaps the most beautiful plant in Chile, while he describes how the foothills of the Andes support columnar cacti painted red by the flowers of the parasitic *Phrygilanthus* that preys upon them. In the sheltered canyons, some thousands of feet below the archæologist's 'Mecca' of Cuzo, where so many remains of Inca and pre-Inca civilizations are still to be seen, the tree tobacco (*Nicotiana tomentosa*) grows in hundreds, while at Machu Picchu the giant perennial *Calceolaria tomentosum* rears its yellow flowers to a height of twenty feet.

But though the botanist will find much of interest scattered through these pages, it is essentially a travel-book in which the risks and difficulties of the journey, the people and the country occupy more space than the descriptions of vegetation and flowers. It is not surprising that cars driven in not too good

a state of repair made the author wish that the native chauffeurs supported their faith and hope by good works, nor that he evidently cherishes a sympathy with Stevenson's dictum that it is better to travel hopefully than to arrive.

We have here, in fact, diversified fare with something to suit most tastes, and if the narrative is at times inconsequent, it is at once easy to relinquish but pleasant to resume. The text is illustrated by a number of excellent photographs, the large majority of a botanical character. E. J. SALISBURY

ORIGIN AND USE OF ATOMIC ENERGY

Sourcebook on Atomic Energy

By Samuel Glasstone. Pp. v+546. (London: Macmillan and Co., Ltd., 1950.) 24*s*. net.

IT is a real pleasure to be able to say that Dr. Glasstone's book on nuclear physics is excellent. It is an account, practically without mathematics, of what we call nowadays 'nuclear physics', with a few extras thrown in. What are its merits? It is complete, with, of course, the exception of the non-descriptive parts of theory. It is eminently readable: the fascinating description of the discovery of fission or the recognition of the neutron in the world are little masterpieces. The author, particularly when discoveries are described, often quotes the original text, which makes it all the more exciting. The book is very up to date (with a slight reservation in the section on cosmic rays) for a tome of more than 500 pages. Berkelium and californium (March 1950) are included, and a real attempt is made to be fair historically, a particular achievement in a field where national ambitions are not always absent. The book is astonishingly free from mistakes.

The first twelve chapters deal with nuclear physics such as radioactivity, accelerators, isotopes and their separation, transmutations, the neutron, nuclear forces and the structure of nuclei. The thirteenth and fourteenth deal with fission and the utilization of nuclear energy, followed by an excellent section on the transuranic elements (neptunium, plutonium, americium, curium, berkelium, californium) and the new elements technetium (43), promethium (61), astatine (85). The article on the uses of isotopes forms chapter 16, and includes labelling of compounds, with selected examples discussed in detail, the application of isotopic tracers in biology, agriculture, industry, chemical analysis, and the beautiful work of W. F. Libby using carbon-14 as an archæological 'clock'. Cosmic rays and mesons are studied in chapter 17. The final, but not least important, chapter deals with health physics, covering such items as radiation meters, radiation dose, remote handling, shielding and the genetic effects of radiations. An author and subject index complete the volume.

The book will obviously appeal to a wide range of readers. Most of it can be read by anyone with a good secondary school education. It should appeal particularly to the medical practitioner and the school science teacher, the student, and anybody who prefers a lively, well-written professional account of the subject-matter to one of the glamorous phantasies which occasionally appear on the market.

The printing is well done, but the photographs are not well reproduced.

The book is sponsored by the United States Atomic Energy Commission and is sent on its way with a foreword by G. Dean, chairman of the Commission. It is good value for the money.

E. BRETSCHER

SOURCE-BOOK OF DATA FOR NUCLEAR PHYSICS

Nuclear Data

A Collection of Experimental Values of Half-Lives, Radiation Energies, Relative Isotopic Abundances, Nuclear Moments and Cross Sections. Compiled by Katharine Way, Lilla Fano, Millicent R. Scott and Karin Thew. (United States Department of Commerce: National Bureau of Standards, Circular 499.) Pp. xiv+309. (Washington, D.C.: Government Printing Office, 1950.) 4.25 dollars+postage; this includes cost of three supplements to be issued half-yearly.

THIS detailed and massive tabulation is intended for critical reference rather than for rapid general survey: it fulfils its purpose admirably. About 1,200 isotopes are known at present, and the editors have allocated ample space to describe each one. They were thereby enabled to make their table much more lucid and detailed than previous compilations of this sort. It contains a lot of information not previously tabulated, and a widespread use of level-diagrams aids comprehension of complex decay schemes. Particularly noteworthy are the internal-conversion ratios of gamma-transitions and an impressive assembly of nuclear cross-sections; the table does not, however, list exact atomic masses. Bibliographic references are given for all the data, and even the reference keys inform by revealing the year of publication. Much of the new information contained in this book comes from American reports which, though available to the public, are not yet readily obtained in Great Britain.

Isotope charts and tables have a habit of drifting out of date, shortly after release, on the swelling flood of new information. This comprehensive new table takes us to the end of 1949 with a peep into 1950, and perhaps its greatest virtue is the specific contract to provide supplements of new data at half-yearly intervals. The table has been designed to allow the assimilation of supplements in loose-leaf form. The present binding is too flimsy to survive much handling, and one wishes that the National Bureau of Standards had made a suitable loose-leaf cover available: it seems, however, that the left-hand margin may prove too narrow, so that the book will not open sufficiently.

Some of the abbreviations used seem unnecessarily cryptic. I regret also the authors' decision not to indicate the reliability of chemical and mass assignments; it is true, as they say, that occasionally assignments assessed as 'certain' have proved false; if one accepts that pretext, much other information should be eliminated from the table. The assessments published previously were the fruits of much careful thought and, with a slightly more stringent use of the *A*-grading, would be sufficiently reliable.

These are minor criticisms; I have no doubt that this work will become a standard authority for nuclear information. J. S. STORY

A Text-Book of General Physics

An Introduction to Mechanics, Properties of Matter and Wave Motion. By G. R. Noakes. Pp. viii+416. (London: Macmillan and Co., Ltd., 1950.) 10*s.* 6*d.* net.

THIS book is a welcome addition to Mr. G. R. Noakes's series of books on physics, and is a worthy companion to the previous volumes. The author deals with the principles of Newtonian mechanics and their application to the study of solids, liquids and gases to a standard required by those students taking physics in examinations at the level of Advanced and Scholarship papers of the new General Certificate of Education. The chief aims are "to encourage a proper attitude of mind towards the subject, to guide the student's progress along the right lines and to lead him to think carefully about the essential physics of a problem before attempting its solution".

This last statement is sound common sense. Mr. Noakes may, or may not, be right in asserting that students find the mathematical aspects of the subject difficult because of the physics, and not the other way round. The writer's experience is that it is the application of mathematics to the solution of physical problems which presents difficulties, probably pointing to the necessity of a greater degree of co-operation in the teaching of mathematics and physics. But whatever the reason, there seems no doubt that mechanics, involving both subjects, is found difficult by many students, and Mr. Noakes is right in advocating learning the subject slowly and surely in stages.

To achieve his aim of winning mastery of the physical principles, the author's approach is experimental rather than mathematical, though the mathematics given is adequate for an intelligent understanding of the problems.

It might seem to some an encroachment on other preserves to include any reference to acoustic problems in a book chiefly on mechanics. But this is quite understandable (after all, the title of the book is "General Physics"), and indeed is all to the good, for apart from other considerations, it does emphasize the interdependence of one branch of physics with the others, which is highly commendable.

The scheme of work is well planned and thoroughly carried out, and the book should certainly be extremely useful to those students who desire a very readable text which presents all the necessary work clearly and fully. T. M. Y.

The Work of the Sanitary Engineer

A Textbook on Water Supply, Sewerage and the Sanitation of Buildings. Based on the original work by the late Arthur J. Martin; rewritten and enlarged by L. B. Escritt and Sidney F. Rich. Pp. xix+689. (London: Macdonald and Evans, 1949.) 42*s.* net.

IN 1935 the late Arthur J. Martin produced a comprehensive handbook on the many-sided work of the sanitary engineer, "for engineers, students, and others connected with public health". This rapidly established itself as a combined text-book and standard work of reference; indeed, it was perhaps the only book to cover, in clear and concise form, so wide a field as that on which the sanitary engineer is required to possess some knowledge, embracing hydraulics, chemistry, bacteriology and geology; and, combined with them, administration and law.

In this revised edition, published under the same title, Mr. L. B. Escritt has been responsible for the technical side, which constitutes the bulk of the work, and which alone is here considered; and Mr. S. F. Rich for the legal. The various sections of Martin's original work have been brought thoroughly up to date, that on water supply having been notably improved. The status of the book has been enhanced correspondingly over the already high standard of the first edition. It is felt that A. J. Martin would have fully approved of this revision, for which his work forms so broad a basis. It is a moot point whether the replacement of flow tables by graphs in the hydraulics section is an entirely desirable feature; it is in accord with modern tendencies, but it is possible for one to become too graph-minded. Of less importance is the inclusion of two quite irrelevant appendixes, respectively on sheep (that is, dew) ponds and the mechanics of the divining rod; their presence is the more remarkable since it is specifically mentioned in the authors' preface that Martin's original section on coast erosion, which in any event was but six pages long, had been excluded on the grounds of irrelevance.

The book has been furnished with a bibliography of 296 references, and with an excellent index. It is well printed, and the illustrations are carefully prepared.

School Laboratory Management

By Arthur Sutcliffe. Second edition. Pp. xi+164. (London: John Murray, 1950.) 6*s.*

ALTHOUGH the larger part of the text of this book is concerned with the chemical laboratory, the physics and biological laboratories are also dealt with, and there is an interesting Nature calendar. The information covers the storage, use and care of apparatus and chemicals, the preparation of solutions and reagents, the furniture of the laboratory, and hints on laboratory discipline. The section on accidents in laboratories includes the legal aspects and a list of dangerous substances. The book is based on experience and can be strongly recommended as likely to be useful to the science teacher in school and to the lecture assistant and storekeeper in university laboratories.

Ulla-Britt and the Birds

By Laurens Sargent. Pp. 116. (London: University of London Press, Ltd., 1950.) 6*s.* net.

LAURENS SARGENT has written a delightful book. Not only children, but adults too, will find pleasure in his "Ulla Britt and the Birds". The story hangs on the experience of a Swedish child, named Ulla Britt, who has her home deep in the forest and loves birds and other animals. Into the story of these experiences the author has skilfully woven his own knowledge of birds, which, as the reader soon realizes, is full and deep. We are told of the coming of spring—of the breaking up of the ice and the melting of the snow—and then the swift arrival of the cranes to feast upon the cranberries (the meaning of the word, the author tells us, is crane berries) which have been imprisoned, full-flavoured, by the snow throughout the winter. I have seen this happen with cowberries, an allied species, in the Cairngorm Hills in Scotland.

Into the book are woven stories and anecdotes. We are told of the life of that great Swedish naturalist, Linnæus or Linné, and how he bestowed his own name on that lowly plant of fragrant flower, *Linnæa borealis*, which is rare in Scotland but numerous in the countries of the north. On p. 94 we learn that the Swedish song thrush and the Swedish robin are shy birds, and thus unlike their British cousins. How many people, adults let alone children, realize that

(p. 98) the raven's tongue is pitchy black, or that (p. 112) the snowy owl, and other owls also, when they perch can put three toes forward, or only two, just as they prefer? We learn of the pigmy sparrow owl (p. 110), which is no larger than a song thrush, and a host of other interesting and useful things. The book is one which should be given to all Nature-loving children as a Christmas or birthday present; it is excellently produced. SETON GORDON

Methods of Mathematical Physics

By Prof. Harold Jeffreys and Dr. Bertha Swirles Jeffreys. Second edition. Pp. xi+708. (Cambridge: At the University Press, 1950.) 84*s*. net.

THE first edition of this outstandingly excellent mathematical treatise appeared in 1946 (see *Nature*, **160**, 139; 1947). The publication of the second edition, as the date—November 1948—of the additional preface shows, has occupied more than a year. The authors, distinguished for their knowledge of mathematical physics and cosmogony, and by their researches in these fields, possess also a remarkably comprehensive and deep understanding of pure mathematics. Their purpose has been to synthesize this mathematical knowledge for the service of physics.

When first published, however, their treatise attracted the interest of some of the most eminent pure mathematicians, whose acute scrutiny of the work led to the discovery of a few errors and gave occasion for comments, which explains some of the changes in the second edition. The total revision undertaken by the authors is considerable. In certain chapters the argument has been simplified or generalized, or the discussion amplified; new subjects have been treated, and most of the notes collected at the end of the first edition are now incorporated into the text. Additions have been made to the interesting collections of examples given at the ends of the chapters, which constitute a useful feature of the book in the Cambridge tradition.

Even more than its original form, the work is a fine product of British mathematical scholarship, and a benefaction to the cause of progress in natural philosophy.

Farm Records and Accounts

By Prof. J. Norman Efferson. Pp. ix+281. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 26*s*. net.

THE merit of this book lies in the skill with which the author has succeeded in giving a straightforward exposition of the main systems of records and accounts needed by farmers, while eschewing any attempt to make it a text-book on agricultural accounting or double-entry bookkeeping. The assumption that "most farmers and students of agriculture do not have and do not need technical accounting training in order to be able to keep and use the records that are adapted to their needs" is eminently sound. By his wholehearted acceptance of this assumption the author has succeeded in writing a book on farm records and accounts which is at once logical, simple and interesting. Anyone who has ever tried the unenviable task of teaching bookkeeping to agricultural students will appreciate that this is no small achievement.

It is inevitable that the American background from which most of the examples and supporting data are drawn limits the value of the book as a 'practical text-book' for British students. But the book itself is a real contribution to the technique of exposition in a difficult field, since it demonstrates that the lucidity of the exposition can be improved by retaining a practical agricultural point of view throughout. E. T.

Thermodynamics of Dilute Aqueous Solutions, with Applications to Electrochemistry and Corrosion

By Dr. M. J. N. Pourbaix. Translated by Dr. J. N. Agar. Pp. xv+136. (London: Edward Arnold and Co., 1949.) 30*s*. net.

DR. M. J. N. POURBAIX has written an extremely stimulating book which has been ably translated by Dr. J. N. Agar. The treatment will be of value to electrochemists and particularly to those interested in metallic corrosion. Reactions are classified and treated systematically, thereby bringing out analogies such as that (p. 30) between the 'solubility' of a metal (affected by potential) and the solubility of a hydroxide (affected by the *p*H). The use of potential/*p*H diagrams leads to the concept of 'domains of stability' or 'domains of corrosion'. In deriving these diagrams, Dr. Pourbaix clearly states the assumptions on which his calculations are based. He also acknowledges generously the contributions of other workers.

Among the subjects discussed are electrochemical affinity, overpotential, the direction of oxidation and reduction reactions, the potentials of conductors in reacting systems and corrosion (including inhibition and passivation). The systems studied in detail are Cu-H_2O, Fe-H_2O, Cr-H_2O and N-H_2O. A list of 137 references and an index are provided.

The book is well produced and there are but few printing errors. Both author and translator are to be congratulated on their treatment of an important and fascinating subject. F. WORMWELL

Dynamics of Real Fluids

By Dr. E. G. Richardson. Pp. vii+144. (London: Edward Arnold and Co., 1950.) 21*s*. net.

THE author has attempted to cover in 140 pages the whole range of fluid mechanics from classical hydrodynamics to problems on rheology. The result is an excellent summary of existing knowledge on a number of diverse topics; but inevitably the treatment is rather superficial in parts. Many sections will convey little to the non-specialist, and some of the statements are rather obscure. Mathematical equations are either quoted or given with but little explanation, and the succeeding steps in the mathematical argument are not always obvious.

After a brief survey of the classical equations of hydrodynamics, there follows a long chapter on fluids of small viscosity. This includes a fairly detailed account of boundary layer problems, and a discussion on periodic flow and turbulence. There follow shorter chapters on compressible flow and heat transfer. The rest of the book deals with topics in which experiment has played a larger part than theory. Free surface problems such as the impact of a solid body on a liquid surface, cavitation and drop formation are reviewed. There follows a chapter on imperfect fluids, such as liquids containing solids in suspension, leading on to questions of erosion. Finally, with a chapter on elastic liquids, the reader is brought up against problems more of a rheological nature.

The text is amplified with numerous references to original papers, but unfortunately it is marred by a considerable number of misprints. J. A. JACOBS

WORLD POWER CONFERENCE

SECTIONAL MEETING IN NEW DELHI

A WORLD Power Conference (Sectional Meeting) was opened in Delhi on January 11 concurrently with the Fourth Congress of the International Commission on Large Dams and the First Congress on Irrigation and Canals. The number of delegates was 770. Of these, 340 were from thirty-eight different countries, and 430 from India. The delegates to the World Power Sectional Meeting alone numbered about four hundred, one-third being from India.

An inaugural address to the joint conferences was delivered by Mr. C. Rajagopalachari, Home Minister of India, who welcomed the delegates and in the course of his speech said that the world needs all sorts of people, but especially those who can discover and conserve natural resources of materials and forces, and can create the means for using these for the benefit and convenience of society with the minimum cost and the maximum useful results. The President of India, Dr. Rajendra Prasad, in a message read at the inaugural meeting, said such meetings provide the best opportunities for collecting the findings and pooling the experience of all participating countries for the greater benefit of humanity. Indeed, such international collaboration in the matter of advancement of scientific technique and knowledge is bound to unite the various nations with ties of goodwill and understanding, and help to establish an easing influence on the international political feeling.

Among other speakers at this meeting, Sir Vincent de Ferranti, chairman of the World Power Conference International Executive Council, stressed the need for adequately harnessing the power resources of the world for the good of mankind. He hoped that the Conference would forge many new ties between the East and West, and expressed the view that men of science, engineers and statesmen working together could raise the standards of living of the peoples to a level never before known. Among the papers to be presented at the Conference, he emphasized particularly those dealing with the use of electricity in agriculture and the co-ordination and development of industries and power resources. During this inaugural meeting, the Indian International Engineering Exhibition in New Delhi was opened by Sri N. V. Gadgil, Minister of Works, Mines and Power. The subsequent sessions of the three conferences were held independently in the Parliament House.

The programme of the World Power Sectional Meeting included forty-four papers submitted by engineers from fourteen different countries, including one delivered verbally from the U.S.S.R. The papers were classified into two broad groups. The first dealt with the use of electricity in agriculture and comprised papers relating to the use of electric power on the farm, in the home, in the processing of agricultural products and in irrigation. The second group included papers dealing with power applied to cottage industry, to light industry, heavy industry, railway traction and other transport, and to mines and power load planning. One paper covered the organization of research for dealing with problems of power generation and utilization. Six sessions were held, each of about three hours in duration, and each under chairmen appointed from different countries. Lord Citrine presided over the first of these. At the commencement of each session a brief résumé of the papers to be considered was given by a reporter who also summed up at the close of the session.

Unfortunately, it had been found impossible, except in a few cases, to circulate the papers in advance of the meetings, so that speakers for the most part made their contributions to the subject under consideration without reference to the printed papers, and sometimes these contributions were only remotely concerned with the subject. Of the papers in the group dealing with the application of electricity to agriculture, that describing rural electrification in the United States was perhaps the most comprehensive; but each paper made some contribution of particular national interest. For example, a contribution from France indicated special measures taken in that country to develop rural loads; a British paper emphasized the benefits derived from the work of the Electrical Research Association and the National Institute of Agricultural Research relating to the supply of electricity for various farm processes including soil warming; "Rural Electrification in Ireland" described attempts to justify on financial grounds the supply of power to isolated farms; a paper from Canada showed how progressive reduction in supply-rates had been achieved by simplifying equipment and by the development of new methods of processing farm products; "Electricity in Danish Farming" described the use of electricity on a co-operative basis which has provided service to 93 per cent of the farms in Denmark; rural electrification in Madras State was considered in a paper which stressed the fact that 80 per cent of India's population live in villages and urged the importance of electrification as a factor in raising the standard of living. The last-quoted contribution described the use of electricity in the drying and withering of tea.

The supply of power to cottage and the light industries was referred to by a number of authors, and all dealt with various economic aspects of the problem. Some stressed the importance of State aid, having in view the desirability in some countries of dispersing into the rural areas the crowded population of the towns. There was some considerable argument on the economic advantages of distributing power in rural areas by single-phase circuits. One author emphasized the need for encouraging the farmer to use electric power by providing knowledge of improved farm techniques and by research into his special problems.

Several papers were devoted to the use of electricity in the production of fertilizers. Of particular interest in this connexion was the description of the Indian ammonium sulphate plant at Sindhri (Bihar State) now under construction, which when completed will have an annual output of 300,000 tons and use continuously about 40,000 kW.

The importance of irrigation to India and other countries in connexion with food production gave special interest to several papers on this subject. One from Egypt discussed the revival of basin irrigation by means of hydro-electric energy, and described interesting methods of combining irrigation and flood control with special reference to the

example of the control of the Nile waters. One from France considered the co-ordination of power development in existing irrigation systems. Another discussed a novel experiment in the United Provinces (India) of large-scale irrigation by lifting sub-soil water by tube-wells, using electric power derived from local low-head hydro-electric plants. Achievements of the Bureau of Reclamation in the United States, which included the use of hydro-electric power in multi-purpose river developments, were described. Apart from satisfying industrial and domestic demands, the electrical power generated from rivers is used in pumping plants to irrigate lands not served by gravity canals. It was urged that a scheme of this nature should be applied in many parts of the world in order to assist in augmenting food supplies for the needs of the increasing populations.

In the second group of papers, those dealing with traction, load planning, and the application of electricity to the light and heavy industries and to mining and metallurgy were most prominent. From the various papers on traction there appeared to be little difference of opinion as to the advantages of electric traction other than as regards the heavy initial capital expenditure. The merits of different systems were discussed in relation to local conditions, and the conclusion was reached by some authors that, owing to the high capital cost, D.C. traction is only justified with high traffic densities.

The economic advantages of A.C. power were discussed in a paper from France which gave information of experiments being carried out both there and in Germany, whereby the use of A.C. power at 50 c./s. can be facilitated and the overall cost of electrification reduced. In this connexion reference was made to the intention of British Railways, some of which operate at special frequencies, to change over to 50-c./s. supply with a view to interconnexion with the National Grid. With regard to power in the heavy industries, papers dealt with statistical information from several countries, indicating what has already been accomplished and what remains to be done. The point was stressed that the entire industrial economy is based on the availability of cheap power and that everywhere heavy industry is 'power hungry'. Information was given of the position in several countries of the present consumption in the major heavy industries such as electro-metallurgical and electro-chemical, in the manufacture of iron, steel and cement, the textile and allied industries, and the extent to which these industries are likely to expand in the future according to national needs. Two valuable papers were presented dealing with power and mines, one being more particularly concerned with problems relating to coal mining, and the other with metalliferous mining.

The papers on research dealt with the facilities needed to assist in providing the most effective plant for electrical power generation and distribution, and included reference to the various types of research organizations in Great Britain and the United States. An important paper from Great Britain on load planning stressed the fact that over the past half-century electricity supply has developed from a purely local amenity to a comprehensive, integrated service in connexion with which long-term planning is essential. It showed the relationship between electricity supply and the various aspects of national economy and gave illustrations of the interrelationships between industrial output and energy consumption in Great Britain and the United States.

A notable contribution that attracted much attention was the reference by Prof. Velander, of Sweden, to an economic survey that had been made in connexion with the transmission of energy over very long distances, in which the use of high-pressure gas of suitable calorific properties compared favourably with electrical power transmitted at extra high tension.

For the reasons already given, there was little discussion on the papers themselves; no very striking contributions came from the considerable number of engineers who spoke, and who for the most part referred to limited personal experience in the subject under discussion, and in some cases gave only a review of already well-known facts. While, in general, the discussion brought out little of value, the Conference was a successful one and of real value not only in providing a permanent record of a great fund of up-to-date knowledge, but also in providing opportunities for individual discussion and exchange of experiences between engineers having similar interests and coming from a number of different countries.

The handling of three large conferences simultaneously, as well as dealing with the impact of the International Engineering Exhibition, was a great feat of organization. The success of the meetings was greatly helped by the availability of Parliament House with its spacious and excellent accommodation, which enabled the three conferences to proceed simultaneously without overcrowding or mutual interference. Apart from the organized programme, advantage was taken of the presence of a number of international experts to hold a discussion on the problem of high-pressure, high-temperature steam for power generation in relation to India's needs. The U.S.S.R. delegates held an informal discussion on engineering problems of their country, to which delegates from other countries were invited.

The World Power Conference ended in Delhi on January 16, after which a large number of delegates joined the two study tours, visiting various industrial centres and engineering plants in India. The tours extended from Amritsar in the north-west to Calcutta in the east, and ended in Mysore in early February. During the Conference delegates were invited to a reception by the President at Government House, to a banquet at the Imperial Hotel, and to a reception by the Institution of Engineers (India) held at Red Fort. A week-end excursion to see the Taj Mahal and the Fort at Agra was organized. Various events of local interest were planned for the ladies of the party.

A. P. M. FLEMING

BIOLOGICAL HAZARDS OF ATOMIC ENERGY

A CONFERENCE on "The Biological Hazards of Atomic Energy" was held at the Royal Institution, London, during October 20–21, 1950, under the auspices of the Institute of Biology and the Atomic Scientists' Association, and with the support of the British Association and the British Institute of Radiology.

A large attendance, representative not only of science and medicine, but also of industry and public affairs, and which contained many overseas observers, left no doubt of the desire for a more general assess-

ment of the social and biological risks of atomic energy than has been available hitherto. The Conference was arranged in four sessions, to which papers were contributed by most of the workers prominent in the field in Great Britain, including a number from the Atomic Energy Research Establishment, Harwell.

The first session (with Sir Henry Dale in the chair) was devoted to the biological and medical effects of nuclear radiations. The opening paper, by Dr. F. G. Spear, on the action of penetrating radiations on normal cells, provided a lucid account of the direct, indirect and constitutional effects, with special reference to the contrast, so far as direct action is concerned, between such threshold types of reaction as the production of erythema and anæmia (in which recovery factors operate), and non-threshold types such as the production of mutations and, in certain conditions, of chromosome aberrations. Dr. L. H. Gray emphasized the great disparity between the degree of biological damage (as measured, for example, by depression of growth-rate) which is induced by the same total amount of energy when delivered to the cell by different radiations. For the purpose of formulating protection recommendations, it has been necessary as a first step to decide upon a maximum permissible rate of exposure to X- or γ-radiation and to relate all others to these by the assignment of a factor representing their relative biological efficiency, the last being correlated empirically with a linear density of ions which ranges, in the particles commonly used in radiobiological research, from about 6 to 4,000 ions/μ. In practice, prudence demands that international recommendations should take account of the largest biological factor likely to be encountered under normal conditions: that such is not unduly cautious is evident from the fact that the largest factor of difference between α- and X- or γ-radiations is observed when minimal damage is delivered in protracted exposures —almost exactly the conditions contemplated in framing protection recommendations. As regards cataract induction resulting from chronic exposure, neutron radiation may be as much as forty times as effective as X-radiation—the highest factor so far reported.

Other contributions in this session dealt with more specific examples in such fields as plant physiology and clinical medicine. Thus, Dr. R. Scott Russell and Mr. R. P. Martin described the considerable accumulations of many elements which plants are capable of building up from dilute solutions: if plants are exposed to any radioactive isotope, accompanied by low or negligible quantities of carrier, there may be a radiation hazard both to the plant itself and other organisms in its environment, an effect which may be enhanced if the element in question is normally absent from plant tissue or present in low concentration. Discussing the relative advantages and disadvantages of iron-59 (half-life 47 days) and iron-55 (4 years) as aids to diagnosis in man, Dr. A. S. McFarlane concluded that, in a situation of many variables, the safety factor might range from about 10 in favour of using one isotope to nearly the same in favour of the other, depending on the distribution of tracer iron in the body, its length of stay, and the type of radiation damage it is desired to avoid. It also appears that biological considerations introduce an uncertainty into dosage calculations with radioiron which is of an altogether higher order than those which ordinarily affect the physical factors: thus, whereas levels of activity which are at present used in normal subjects are safe on the basis of the knowledge available, the same levels ought not to be used indiscriminately in clinical practice. Dr. E. E. Pochin, in an account of the clinical use of radioiodine, described the great practical service of iodine-131 in both diagnosis and treatment. Ingestion of the radioelement can be assessed with high sensitivity by gamma-counting over the thyroid, and amounts can be detected which are considerably less than would administer 0·05 r. daily to the gland. From the data provided, it appears that reasonably high dosage of radioiodine can be given with low contamination by the use of very simple equipment and precautions; in purely investigative work, where the total dosage is one-hundredth or less, it seems, indeed, that hazard would result only from negligence.

With Sir John Cockcroft in the chair, the second session, on tolerance-levels and protection, opened with an invaluable summary by Prof. W. V. Mayneord of the history and organization of protective measures, from the first recommendations of the British X-ray and Radium Protection Committee in 1921, the Commissions on Units and Protection of the series of International Radiological Congresses begun in London in 1925, and the 1931 report of the Health Organization of the League of Nations. With the radical change brought about by the developments in physics from 1940 onwards, the problems now faced—such as atmospheric contamination by gaseous or particulate matter, and the disposal of radioactive wastes—are infinitely more complex than previously. In Great Britain, the main burden of such problems has fallen upon the Medical Research Council's Committee on Medical and Biological Applications of Nuclear Physics, and in particular its Protection Committee and the sub-committee known as the Tolerance Doses Panel. The last—with assistance from the important Chalk River and Buckland House Conferences of 1949 and 1950 respectively—made recommendations via the main protection Committee to the International Commission on Radiological Protection which met during the recent Sixth International Congress of Radiology in London (see "International Recommendations on Radiological Protection", *Brit. J. Radiol.*, **24**, 46; 1951). In these international recommendations, not all of which are firm, and which relate to the maximum permissible amounts of isotopes in the body and to maximum permissible exposures to X- and γ-radiation, high-energy beta-rays and fast neutrons, it may be noted that the maximum permissible dose of X- or γ-radiation of quantum energy less than 3 MeV. which it is recommended may be received by the surface of the body in any one week, namely, 0·5 r., represents a reduction by a factor of about two from the original recommendation of the Committee in 1928. The foregoing deals with protection problems in atomic research and industry, but in wider issues of the protection of whole populations, for example, from contamination of their water supplies, responsibility lies eventually with the Ministry of Health, the statutory committee of which, now set up to implement the Radioactive Substances Act, itself has a Protection Committee. So far as concerns future policy and development, attention is directed to Mayneord's opinion that there should be, in the composition of such new committees as are suggested by the International Commission, a far higher representation of experimental biologists

(especially in experimental physiology, pathology and genetics), and of medical men conversant with such industrial health problems as dust hazards and water pollution.

It must always be a question to what extent agreed or recommended standards, however well devised, can, in fact, be attained in practice; and in this connexion much valuable and indeed encouraging information was provided by Dr. W. G. Marley's account of the exposures actually incurred in operations at the Atomic Energy Research Establishment, Harwell, during 1949. After monitoring, through the issue of film badges to all persons having access to areas where the dose-rate might on occasion exceed one-tenth of the maximum permissible level of 0·5 roentgen-equivalent-physical ('rep') per week, supplemented by pocket ionization chambers or dosemeters in instances where a high dose might be received in a short time, the results obtained from more than 51,000 badges issued (weekly) during 1949 showed that the maximum permissible level was exceeded on only 24 occasions, and that the highest individual exposure during any one week was 3 r.; all individual cumulative exposures were well below the maximum permissible annual exposure of 26 r. On the other hand, Dr. Marley indicated more recent instances in which somewhat higher exposures have been recorded. It has also been found that staff engaged in the production of radioactive isotopes normally incur a regular weekly exposure, although in most other cases the annual cumulative exposure is largely made up from one or two isolated high exposures and not from the steady accumulation of regular doses. Fast-neutron surveys, in the region over 20 MeV., have recently been carried out around the cyclotron: the six feet of concrete shielding is found to be quite adequate, the fast-neutron flux outside the cyclotron pit being well below tolerance when the machine is running with a beam current of one microampere of 165-MeV. protons. In control of activity outside the active laboratories, the air is filtered to remove radioactive dust before discharge from a 200-ft. stack. But the presence due to neutron capture of a small amount of the 110-minute radioactive isotope argon-41 gives rise to a slight change in background downwind, although only to levels which are negligible in relation to the maximum permissible level for gamma-radiation of some 200 times background. In the control of laboratory contamination, responsibility rests primarily with the staff, but systematic weekly surveys are also made by the Health Physics Division; in the majority of cases there is no difficulty in maintaining contamination at a low level, although high levels periodically arise, especially in isotope production. Such experience is mainly with contamination from work carried out in open-fronted fume-hoods, in contrast with the present trend towards the use of closed dry-boxes under reduced pressure.

As indicated, the handling and disposal of radioactive wastes is certain to be a major consideration in future development. For the moment it is certainly of interest to know that the level fixed for activity in the Thames, expressed in terms of the equivalent radium content, is only a fraction of the actual radium content of the water drunk by the population of New York. Impressed as we must be by the record of Harwell experience in 1949, this is not to say we should overlook such less encouraging opinions as that of Prof. R. M. Sievert as expressed in a paper on tolerance-levels and radiation protection in Sweden, where government supervision, in all forms of radiological work, has applied since 1941. In Prof. Sievert's view, the optimism which earlier obtained is now felt to be unjustified, since knowledge of the biological action of small doses and intensities in man is clearly too incomplete—particularly in respect of extreme fractionation and long periods of irradiation—to provide a reliable basis; furthermore, measurement of the true dosage received may involve far greater difficulty than is generally assumed. Other papers in this session considered the evaluation of tolerance-levels generally (Dr. G. J. Neary), and of tolerance-levels for fast and thermal neutrons (Prof. J. S. Mitchell), the control of radiation hazards with special reference to material which has been ingested or inhaled (Mr. W. Binks), and the possibilities of physical, chemical and physiological protection against massive doses (Dr. J. F. Loutit).

The third session (chairman, Sir Ernest Rock Carling) proceeded to examine the various biological implications of the facts thus far brought forward and, in particular, the long-term genetical hazard. According to Dr. C. D. Darlington, the hazards of evenly distributed irradiation depend on increase of mutation-rate beyond the level at which the mutations can be conveniently stored in the population. This level is now being affected by two changes in the conditions of human society, neither of which can be accurately measured: the rate of storage is being increased by a higher degree of outbreeding, and the rate of elimination of unfavourable mutations, the selection-pressure, is being reduced. These and many other genetical considerations were comprehensively reviewed by Prof. K. Mather in what was clearly one of the most valuable and important papers in the series. In Mather's view, while the genetical unbalance due to radiation-induced changes in chromosome structure, and the more drastic gene mutations, must both in general be unconditionally deleterious, this is not necessarily true of smaller changes. On the other hand, only a small fraction of even the mildest changes can be immediately helpful, so that gene mutation is disadvantageous on any but the longest view. Further, in so far as the genetic effects are cumulative, even the smallest doses applied at the lowest intensities will add their quota, and sooner or later the effects of even recessive mutations will be seen, although long delayed. On the basis partly of calculation and partly of assumption, it does, however, appear that if half the radiation given to the gonads is to the gonads of individuals of effective breeding age or younger, some 30 units given annually to the gonads of 1 per cent of the population would raise the mutation-rate by only 10 per cent. It may therefore be concluded that radiation reaching the gonads will increase suffering and distress in later generations—and hence should be minimized by every reasonable precaution—but that it is unlikely *at present levels* seriously to jeopardize the future of the species. Mather's paper was noteworthy for its careful treatment of the many assumptions upon which much current reasoning is necessarily based—for example, that the same principles of genetic equilibrium hold in man as in other species—and for making clear the extent to which prediction will depend upon our knowledge of the genetical structure of society, as well as of the genetical effects of radiation.

Meanwhile, the lack of such accurate knowledge is not unnaturally reflected in some difference of

emphasis and opinion between individual workers. Dr. D. G. Catcheside, considering a dose of tolerance-order amounting to 300 r. in a generation and continued over a large number of generations, believes that the 'minor' part of the resultant defects, tending to reduce the fitness of many apparently normal individuals, may well be considerable, with a serious or even disastrous total effect. Dr. E. B. Ford acknowledged that the genetic effect of atomic energy must be entirely bad through increase in the sum of human wastage from heritable disease, but believes it need not hamper the course of human progress in a wider sense. The difficulties of prediction, however, were emphasized by Dr. G. Pontecorvo from another aspect, namely, the fate of cells descendant from individual cells of an irradiated tissue. The dose-effect relationships well established in *Drosophila*, at least for doses above a few tens of roentgen units, are valid exclusively for irradiation of non-dividing mature spermatozoa, and cannot be extrapolated to earlier stages of the germ track. Thus, while we may be able to calculate the amount of radiation necessary to double the mutation-rate when applied to mature *Drosophila* sperm, we have no basis for conjecture as to the requisite increase over a life-cycle. At present we know nothing of the cell population dynamics linking the irradiated cell with genetically-determined changes in later generations, and some of the most urgent problems of radiation genetics appear to lie in this field. Another effect of penetrating radiations upon purely cellular genetics was considered by Dr. A. Glücksmann—the induction of cancer in a localized region by large doses, the co-carcinogenic potentiality of doses at therapeutic levels, and the remote carcinogenic effects of doses near tolerance-levels, as shown by the induction of leukæmic and ovarian tumours in mice. There is no evidence for the last effect in man, but the possibility cannot be excluded that minute doses of radiation may on occasion promote carcinogenesis in disposed individuals, so that the permitted level of radiation exposure should be reconsidered periodically in the light of such facts. Other papers dealt with the attempted induction of visible mutations in mice by chronic gamma-irradiation (Dr. T. C. Carter and Miss Rita S. Phillips), the gross biological hazard in the use of strontium isotopes (Dr. Janet Vaughan, Miss Margaret Tutt and Miss Barbara Kidman), and the measurement of the normal radioactivity of the body (Prof. F. W. Spiers and Mr. P. R. J. Burch)—the last includes reference to projected apparatus in which the limit of significant measurement will be set mainly by the cosmic ray component, with an expected standard deviation of less than 1 mμgm.

Thus far the Conference may well be claimed to have been highly successful, in providing a balanced (and in some ways reassuring) account of the present contribution of atomic energy to radiation hazards. Since, however, the future is certain to bring greatly increased development and application, both peaceful and military, correspondingly increased dangers will clearly require to be faced for an indeterminate period to come. Under the chairmanship of Lord Boyd-Orr, the last session made a brave endeavour to consider these problems of the future, with their attendant and inescapable questions of human responsibility. Sir George Thomson, dealing with the importance of future developments for power, emphasized the serious if not insuperable problems likely to arise from increasing numbers of reactors, and briefly considered the contamination effects of atom bomb explosions in air-, water- and ground-bursts respectively; many must have been disappointed not to hear from him some development of those views on the even more formidable problems of the hydrogen bomb, expressed in his Chatham House address last year (*International Affairs*, **26**, 463; 1950).

If earlier sessions provided a factual appraisal for the present, the last session allowed a glimpse of a future situation which can only be met by more knowledge, by the best use of the knowledge already available, by a great increase in the influence of the biologist in his discussions with the physicist, technologist and engineer, by a frank recognition of the particular responsibility of the scientific worker in all matters affecting the use and misuse of atomic energy, and by the complete abandonment of that secrecy which, in Prof. K. Lonsdale's words, "should be anathema in any civilized community, particularly in a scientific community, no matter what its alleged justification".

The proceedings of the Conference will be published in due course by the Clarendon Press, Oxford.

QUALITATIVE ASPECTS OF THE CHEMISTRY AND BIOLOGY OF RADIOMIMETIC (MUTAGENIC) SUBSTANCES

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A RECENT communication[1] set forth the precise biological criteria upon which chemical substances may be classified as radiomimetic and thereby distinguished from other types of 'mitotic poisons'. Cytologically, the term 'radiomimetic' must be restricted to those substances which can be shown unequivocally to react upon the resting cell in such a way as to produce an alteration of the genetic material which is revealed by the appearance of chromosome breakage and rearrangement in subsequent divisions. It is becoming evident through work of geneticists, notably Auerbach and Robson[2], Rapoport[3–6], Demerec[9] and Bird[10], that these substances are also mutagenic. Probably the converse is true, namely, that compounds which are radiomimetic as judged by genetical tests are also capable of producing visible chromosome effects in somatic tissues. Since, however, certain compounds have been claimed to be mutagenic without radiomimetic effects having been demonstrated cytologically, the word 'mutagenic' is enclosed in brackets in the title of this article.

Again, the terms 'radiomimetic' and 'mutagenic' have both qualitative and quantitative aspects. Thus, Auerbach[8] found that the proportion of translocations and sex-linked lethals produced in *Drosophila* by mustard gas was not the same as that produced by X-rays. Ford[11] observed that 'nitrogen mustard' (methyl-di-2-chloroethylamine) gave a different pattern of breakage in *Vicia* chromosomes to X-rays; Revell (ref. 1 and unpublished) has extended these findings to other substances of the radiomimetic class and endeavoured to relate high-breakage regions to the distribution of heterochromatin as defined by

low-temperature sensitivity. Accordingly, the results of our recent work will be reported in two parts. The present communication deals with the relation between chemical structure and radiomimetic activity. A later paper, written jointly with Mr. S. H. Revell, will describe the methods employed and the results obtained in a precise analysis of the cytological effects of active compounds in comparison with X-rays.

Material and Methods

Throughout the majority of the work, root tip meristems of *Vicia Faba* have been used as a test object; a few experiments have also been done with larvæ of *Triturus palmatus*. It is necessary in an experiment of this kind that the duration of treatment be limited, so that immediate toxic effects and true genetic effects of the substance under test may be distinguished[1]. The assumption has therefore been made that the effect is determined quantitatively by the product of concentration and time. (It is appreciated that the concentration of reagent to which the material is exposed may not bear any direct relation to the concentration at the site of action in the cell. However, we are here dealing with compounds that act by covalent bond formation and not with indifferent substances of a narcotic type.)

Exposure of the roots to solutions of the compounds was, therefore, limited to one hour, and a wide series of concentrations was tested. Samples were taken at 4–6 hours after treatment for the observation of immediate effects on those cells already in division at the time of treatment, and at 18, 24, 36 or 48 hours as necessary to determine the effect upon cells in the resting stage at the time of treatment. Preparation of material for microscopic examination throughout the series of experiments reported here was by the Feulgen squash method.

Choice of Compounds for Test

At first, attention was mainly focused upon compounds of the mustard type, since they are known to be radiomimetic and mutagenic and particularly, owing to the development of aliphatic- and aromatic-type nitrogen mustards by Goodman *et al.*[13] and Haddow, Kon and Ross[15] respectively, as growth inhibitors. Moreover, the chemical reactions of both sulphur and nitrogen mustards have been extensively studied, and it was known that these compounds react readily with the $-NH_2$, —SH, carboxyl and imidazole groups of proteins and with amino- and primary and secondary phosphoryl groups of nucleic acids. The reactions of aromatic nitrogen mustards with amines, thiols and anions have recently been extensively studied by Ross and colleagues[14–17].

In an attempt to decide which of these reactions were significant in determining the chromosome changes, a range of compounds was tested, designed so far as possible as selective reagents for the individual groups concerned. In the first instance, only bifunctional compounds were employed, but, where activity was found, monofunctional analogues were also tested. Sulphydryl reagents were the first selected in spite of the fact that the —SH reaction appears to play little part in the determination of other biological properties so far as sulphur mustard is concerned[18]. The choice was largely influenced by the belief held by many workers[19–21] that sulphydryl compounds play a vital part in cell division and growth and in the function of allegedly 'radiomimetic' poisons[22,23]. In addition, Ogston[24] has demonstrated a very high 'competition factor' for mustard gas exerted by certain —SH compounds. Three main types of —SH reagent were employed, namely, iodoacetyl derivatives, organic arsenicals and unsaturated compounds of various double-bond characteristics. Some of these compounds may also react with amines, but in addition certain other amine reactants, notably carbonyl compounds, were tested. Thirdly, various reagents have been investigated which, like the mustards, are electrophilic, that is, they tend to react predominantly with free amino-groups and anions. Ross[17] has demonstrated that the groups most likely to react *in vivo*, assuming that the *p*H at different cell-sites does not vary appreciably from neutrality, are acid anions and certain aromatic-type amino-groups in nucleic acids.

The types of compounds chosen were largely based upon a list drawn up by Dr. W. C. J. Ross and myself more than two years ago as part of a programme designed to test the value of the cross-linkage hypothesis[25]. During the course of this work, the results of Ford and of Revell, already noted, became available, and an explanation was being sought for the apparent difference between the effect of X-rays, which was assumed to be mediated by a free-radical mechanism, and that of mustards and epoxides, which almost certainly act by alkylation or esterification. Hence, peroxides and per-salts which might act as chemical sources of hydroxyl radicals were also examined, especially since compounds of this type had been found by Dickey, Cleland and Lotz[26] to produce mutations in *Neurospora*. The results of these tests will be indicated briefly and dealt with more fully elsewhere in the later paper.

Results

Biological effects may be classified as 'pycnotic' or 'radiomimetic' (mutagenic). The former include effects such as 'stickiness', anaphase lagging, 'sticky' bridge formation, and metaphase and telophase pycnosis, which are observed in cells dividing at the time of, or very shortly after, treatment.

It is true that intercalary stickiness at anaphase may occasionally result in fragment formation during anaphase (cf. Levan[27], D'Amato[28]), and this may partly account for the low incidence of mutations after treatment with non-radiomimetic agents, for example, allyl isothiocyanate and dichloroacetone[29].

Bifunctional Compounds

—SH *Reagents*. Those tested included the following: 1 : 2 di-(iodoacetylamino)benzene, 1 : 2 di-(iodoacetoxy)benzene, *sym* di-iodoacetone (analogous to dichloroacetone), *o*-xylyl dibromide, 4-amino 3-hydroxy-phenyl arsenoxide, β-chlorvinylarsonic acid, lewisite, divinyl ether, diallyl sulphide, diallylamine, diallylaniline, methyldiallylamine, diallylaniline methiodide, divinyl sulphone, dichlorodiethyl sulphone, protoanemonin, anemonin, patulin, hydroquinone, benzoquinone, allyl isothiocyanate. (The first substance, 1 : 2 di-(iodoacetylamino)benzene, has been reported as producing radiomimetic effects in *Triturus* (Goldacre *et al.*[25]), but subsequent experiments have failed to repeat the result.) Of these, many gave pycnotic effects, but only protoanemonin, divinyl sulphone and, to a lesser extent, dichlorodiethyl sulphone were, in addition, radiomimetic. Unsaturated compounds in this list have been chosen to include examples with neutral groups (O), electron-repelling groups (N,S) and electron-attracting groups

(N^+, SO_3, lactone) adjacent to the double bond. Probably the first two types do not readily undergo addition reactions; in the third case, the double bonds are highly polarized and will react readily with nucleophilic groups.

—NH_2 *reactants*. The original list included certain amino-group reagents, such as ketenes and isocyanates, which it has not been considered profitable to pursue owing to the synthetic problems offered and the instability of such compounds in water. One acid chloride, *sym* phthaloyl chloride, has been tested and found inactive, but subsequent examination by Dr. Ross (private communication) has revealed that this compound undergoes very rapid hydrolysis in water. The remainder which were tested are as follows: glyoxal, diacetyl, acetyl propionyl, phthalaldehyde, formaldehyde, methylal, resorcinol dichloroformate. None showed radiomimetic behaviour.

Electrophilic reagents. The nitrogen and sulphur mustards have been re-investigated for certain limited purposes: to determine the order of concentration required to give optimal effects in *Vicia*, and to investigate the possible influence of basic substituents. Diepoxides were prepared by Mr. J. L. Everett and Dr. W. C. J. Ross, of this Institute, as a development of the cross-linkage hypothesis (cf. Loveless and Revell[1], Speakman[20], and Deuel and Neukom[21]). In addition, a bi- and a tri-functional derivative of ethylenimine were examined.

All types proved to be effective radiomimetic agents and to show no non-specific toxic or pycnotic effects at active concentrations. Compounds tested were: mustard gas (dichlorodiethyl sulphide), nitrogen mustard (di-2-chloroethyl methylamine), dichlorodiethylamine, NN-di-2-chloroethyl-*p*-phenylene diamine, 1 : 2, 3 : 4-diepoxybutane, di(2 : 3-epoxypropyl)ether, 1 : 4 di-(2 : 3-epoxypropoxy)-benzene, diethylenimino phenyl methane, 2 : 4 : 6 triethylenimino-1 : 3 : 5 triazine.

Monofunctional Compounds

Four types of bifunctional compounds have thus been found active, namely, sulphur and nitrogen mustards, diepoxides, ethylenimines and unsaturated compounds, in which a strongly electron-attracting group is immediately adjacent to the double bonds. Monofunctional analogues of these have therefore been investigated.

Mustard series. The first compound found active was a monofunctional analogue of mustard gas itself, ethyl-2-chloroethyl sulphide. A comparable 'one-armed' nitrogen mustard, dimethyl-2-chloro-ethylamine (analogous to methyl-*bis*(2-chloroethyl)-amine), was afterwards found active when tested at comparatively high concentration and the solution made slightly alkaline to ensure that most of the compound was in the form of the free base.

Epoxide series. Low activity on the part of epichlorhydrin and butadiene-monoxide was discounted on the ground that neither was strictly a monofunctional compound. However, ethylene oxide has now been found to be moderately active, while Bird[10] has confirmed the earlier results of Rapoport. Consequently, there can be no doubt that at least some mono-epoxides are capable of acting as radiomimetic compounds within the limits of the present test.

Ethylenimine series. Ethylenimine itself has been found to be an efficient radiomimetic agent. In this case, however, one cannot be sure that the compound is acting as a monofunctional reagent since, upon reaction, a primary amino-group is produced which might act as another functional centre in the molecule. This possibility is of special concern since putrescin (1 : 4 tetramethylene diamine) has been described[22] as producing chromosome breakage. Although this substance has not been tested in the present work, cadaverine (1 : 5 pentamethylene diamine) has yielded negative results.

Unsaturated compounds. Two substances with strongly electrophilic double bonds have been examined, namely, acrolein (found to be mutagenic for *Drosophila* by Rapoport) and acrylonitrile; both were found inactive. This is not perhaps surprising, since both divinyl sulphone and protoanemonin only showed radiomimetic behaviour at barely sub-lethal doses, and it has been found necessary in other cases to use considerably higher concentrations of mono- as compared with bi-functional compounds. The toxic concentrations of acrolein and acrylonitrile are such, however, that comparable concentrations cannot be employed.

Miscellaneous. Dimethyl sulphate has also been tested in view of Rapoport's findings and found to show a high degree of activity. Diazomethane, on the other hand, is inactive in this test; it can, however, only esterify unionized acids.

Except for the nitrogen mustards, where special conditions apply, the ratio of active concentrations as between mono- and poly-functional analogues shows the remarkably high value of about 1/50. Though these concentrations are admittedly not precise and do not necessarily bear a direct relation to that obtaining at the site of action, nevertheless the constancy of this difference is probably not without significance. It must be confessed that no satisfactory explanation is at present available to account for the disproportionate increase in activity that accompanies the insertion into the molecule of a second reactive group.

Peroxides and Per-salts

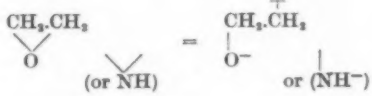
A purified specimen of tert.-butyl hydroperoxide (which is used as an initiator of polymerization reactions in the plastics industry) was found active in producing breakage and rearrangement of *Vicia* chromosomes under the conditions employed, and incidentally the compound does not appear to be decomposed by catalase. Dickey, Cleland and Lotz[23] have, in addition to this compound, employed aqueous mixtures of carbonyl compounds—formaldehyde and acetone—and hydrogen peroxide in their experiments with *Neurospora*. Formaldehyde may form dihydroxymethyl peroxide in aqueous hydrogen peroxide, and such a mixture was found in our experiments to produce a low incidence of chromosome breakage at just sub-lethal concentrations, controls performed with either component alone giving only negative results. It is conceivable that stabilization of naturally formed hydrogen peroxide may account for the results of Rapoport[3] and Auerbach[22] using formaldehyde.

The positive result obtained with tert.-butyl hydroperoxide (which has also been reported as producing erythema and vesication[24]) made it imperative to examine simple peroxy compounds in everyday use; sodium perborate, which is attacked by catalase, and sodium persulphate, which is not,

were both found inactive. The inactivity of these and hydrogen peroxide itself suggests that the active principle may be an alkyl radical and not hydroxyl, especially since alkyl radicals may exist in equilibrium with the corresponding ion in solution.

It appears that compounds which will react readily under physiological conditions only with —SH and —NH_2 groups, even though they be bifunctional, do not in general produce radiomimetic effects. Consequently, it is necessary to re-examine the properties of the two apparent exceptions—divinyl sulphone and protoanemonin—to ascertain whether they take part in other reactions. First, we may consider the basis of reactivity of the third class of compounds showing a high order of biological activity. It has been stated that these are all electrophilic reagents, this property being determined by their ability to yield a carbonium ion, that is, take up a form in which a positive charge resides on one of the carbon atoms. This is achieved in the mustards by ionization of the halogen atom, which occurs as a unimolecular reaction in aqueous solution and is facilitated by the electron-repelling character of the nitrogen or sulphur atom, as already described[1]. The carbonium ion can now react with water or with a nucleophilic centre; but the rate-determining step is the primary ionization, which is independent of the concentration of the second reagent. A full treatment of this subject can be found in the chemical literature, for example, Ogston[24] and Ross[25].

The reaction of epoxides and ethylenimines is consistent with the assumption[26] that the ring opens with the formation of a carbonium ion, thus:



This likewise will react with water or a nucleophilic centre, and a hydrogen ion will add to O^- or NH^-. However, there is a contrast between these and the mustards in that the ring does not open except under the polarizing influence of a reactant. The reaction is thus bimolecular, and its rate determined by the concentration of reacting substrate; it might be expected that the two types would show differing degrees of selectivity in their action.

It can now be seen that the active unsaturated compounds have similar features. Thus, the electron-attracting group will cause a displacement of the mobile π-electrons of the double bond with the resulting polarization of the bond and the production of a positively-charged terminal carbon atom. The capacity of the double bonds to react with anions is confirmed by the fact that divinyl sulphone reacts with the thiosulphate anion, which has a very high rate of competition for the carbonium ion. As a further test of this principle, Ross (in the press) has examined the reactivity of some unsaturated aldehydes and esters toward thiosulphate and has shown that a significant reaction only occurs where the vinyl group is unsubstituted and immediately adjacent to the electron-attracting centre, for example, acrolein, acrylonitrile and acrylic ester, but not methacrylic ester, crotonaldehyde, crotonic ester or cinnamic aldehyde.

However, reaction with groups other than anions is strongly favoured since the double bond, being at all times polarized, is able to polarize and react with other groups in turn, especially —SH and —NH_2. Moreover, esters derived by reaction with acid anions are liable to be very unstable. Divinyl sulphone is thus one of the least active of the radiomimetic class and has a high toxicity. In the absence of experimental evidence, it is assumed that the activity of protoanemonin depends upon a similar mechanism. The very low activity of dichlorodiethyl sulphone must be related to the ease with which it loses hydrogen chloride to give divinyl sulphone (cf. Boursnell *et al.*[27]).

So far, it appears that all the genetically active compounds discussed have the common property of reacting by a carbonium ion mechanism. If Ross's assumption, as already referred to, is correct, it seems difficult to avoid the conclusion that the biologically significant reaction is an esterification of ionized acids. The possibility of direct action with nucleo-protein aggregates in the resting nucleus has previously been suggested.

It remains to consider whether other radiomimetic or mutagenic agents can be accommodated within the same general plan. Work with peroxides is as yet in its early stages, and more will be said concerning this in the later paper. Nevertheless, it has already been proposed by Ross[28] that there are points of similarity between free radicals and carbonium ions.

Many of the compounds which Rapoport has claimed to be mutagenic, such as diazomethane, diethyl sulphate and, as we have seen, acrolein, react readily as esterifying agents. It is, however, evident that certain mutagens such as phenol[39], urethane[40,41], carcinogenic hydrocarbons, β-naphthylamine[9] and caffeine[42] fall into a different category both chemically and, in so far as their level of mutagenic activity is concerned, biologically. It is not out of the question, however, that some of them should be converted to reactive derivatives, for example, epoxides or peroxides, *in vivo*.

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Summary

Tests with a considerable range of mono- and poly-functional alkylating and esterifying agents for radiomimetic activity in *Vicia* have shown that only those compounds are active which are capable of reacting by a carbonium ion mechanism. While both mono- and poly-functional types are active, the latter show a very much higher degree of activity; no entirely satisfactory explanation of this fact has been proposed.

The results suggest that activity resides in the high degree of selectivity of reaction with anions which is manifested by the group, and that the significant reaction *in vivo* is probably an esterification. The radiomimetic activity of organic peroxides is also reported, and the suggestion offered that certain mutagens, for example, formaldehyde, may act through the intermediate formation of organic peroxides by reaction with naturally produced hydrogen peroxide. It is suspected that the activity of organic

peroxides lies in their ability to liberate alkyl rather than hydroxyl radicals.

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OBITUARIES

Prof. Harald Bohr

No doubt the reason why the death of Prof. Harald Bohr, of Copenhagen, was reported in English newspapers was that he was the brother of Niels Bohr, the famous atomic physicist. Actually he was a great man in his own right, one of the leading figures in the generation of mathematicians which also contained Hardy, Landau and Littlewood. His fame will rest chiefly on his invention of the theory of almost periodic functions. Incidentally, he was perhaps the only front-rank mathematician who was also an international footballer, as he had played football for Denmark.

Harald Bohr's early work was mainly on the theory of the Riemann zeta-function,

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s} = \sum_{n=1}^{\infty} \frac{1}{n^{\sigma+it}}.$$

The sort of problem which he considered was this. Suppose that we take a fixed value of σ, greater than 1, and consider the behaviour of the function as $t \to \infty$. The nth term of the series is periodic, with period $2\pi/\log n$, but the function as a whole is not periodic. Nevertheless, Bohr showed that it imitates to a certain extent the behaviour of a periodic function. It has oscillations which never die out as $t \to \infty$, and these oscillations are very large when σ is very near to 1. Thus $\zeta(s)$ is unbounded, as $t \to \infty$, in the neighbourhood of the line $\sigma = 1$. Bohr constructed many beautiful proofs of this and other theorems in the same order of ideas.

It was no doubt his work on the quasi-periodic properties of the Riemann zeta-function that led Bohr to the idea of an almost periodic function. The function $f(x) = \cos x$ is periodic, with the period 2π, that is, $f(x + 2\pi) = f(x)$ for all values of x; so is $f(x) = \cos\frac{1}{2}x + \cos\frac{1}{2}x$, its period being 12π. It is known from the theory of Fourier series that any periodic function can be expressed as a sum of such trigonometrical functions. But the sum of two periodic functions is not necessarily periodic, as is shown by the example $f(x) = \cos x + \cos(x\sqrt{2})$. The problem which Bohr set himself was to find a property analogous to periodicity which characterizes all such functions. His result is as follows. A number y is called a translation number of a function $f(x)$, belonging to a number ε, if $|f(x+y) - f(x)|$ never exceeds ε, for any x; and $f(x)$ is said to be almost periodic if the translation numbers corresponding to any ε, however small, are relatively dense, that is, if there exists a number l such that any interval of length l contains at least one such number. Bohr showed that any almost periodic function can, in some sense, be expressed as a trigonometrical series of the form $\Sigma A_n \exp iA_n x$. His theory thus amounts to a wide generalization of the theory of Fourier series.

E. C. Titchmarsh

Prof. G. T. R. Evans

Gwilym Thomas Richard Evans, professor of physics in the University of the Witwatersrand, Johannesburg, died on December 20, 1950, after a short illness. He was sixty years of age. He was a native of Cardiganshire, Wales, born at Talybont near Aberystwyth. He became a student of the University College of Wales, Aberystwyth, taking his B.Sc. degree with honours in physics in 1913. He was immediately appointed to the physics staff of that College. But for a break of several years spent at a munitions factory in South Wales during the First World War, he remained at Aberystwyth until 1920, when he left to take up an appointment in South Africa as lecturer in physics at what was then the Johannesburg University College. He soon became a senior lecturer in the newly constituted University of the Witwatersrand. He was appointed to the chair of physics in 1947 and became dean of the Faculty of Science in 1950. He was a Fellow of the Institute of Physics.

Prof. Evans carried out research on electrolytic conduction and on the preparation and coagulation of colloids both in Aberystwyth and in Johannesburg, and published several papers on these topics. He was an excellent teacher and administrator. During

the course of his service at the University of the Witwatersrand, he came in contact with some thousands of students, mainly in science and in engineering, and left a lasting impression on them by his sympathy and encouragement as well as by his enthusiasm as a teacher. During the last three years, he organized overseas study leave for the members of his staff to enable them to obtain training in metal physics, so that they might return and form a team of workers in that subject.

He is remembered with great affection by his colleagues in the University and by a wide circle of friends outside. He leaves a widow, a son and a daughter.

H. H. PAINE

WE regret to announce the following deaths:

H. J. Hodsman, M.B.E., senior lecturer in the Department of Coal Gas and Fuel Industries, University of Leeds, on January 31.

Dr. C. Ramalinga Reddy, vice-chancellor of Andhra University, and a member (1941) of the All-India Board of Scientific and Industrial Research, on February 25, aged seventy.

NEWS and VIEWS

Educational Psychology at Durham: Prof. F. V. Smith

PROF. F. V. SMITH has been appointed to the chair of educational psychology in the University of Durham, with responsibilities for the subject at both Durham and King's College, Newcastle, in succession to Prof. E. A. Peel, who has taken the chair of education in the University of Birmingham. Prof. Smith is an Australian who graduated at the University of Sydney with high honours in psychology. He had experience in administration and lecturing in education in Sydney, being responsible particularly for the diagnosis and remedial treatment of children's educational disabilities. He went to London in 1946 as a lecturer at Birkbeck College, obtaining the degree of Ph.D. of the University of London, and then he became lecturer in experimental psychology in the University of Aberdeen in 1948. Prof. Smith's main contributions have been in the field of Gestalt and Hormic psychology. He believes that a real understanding of pure psychology is essential for furthering progress in its educational and industrial applications. He is a keen traveller and photographer, and is particularly fond of mountain sports both in summer and winter.

Honorary Citizenship of the University of Hamburg: Dr. J. N. Carruthers

ON February 9, the rector of the University of Hamburg, Prof. Jores, conferred the Diploma and Gold Medal of the Citizenship of Honour of the University on Dr. J. N. Carruthers, of the Admiralty Hydrographic Department. Among others, representatives of the German Geophysical Society were present at the ceremony, which took place in the Geographical Institute of the University. In his address Prof. Jores paid tribute to Dr. Carruthers's achievements in the field of oceanography and the exploitation of its results for fishery biology, from which, he said, all nations bordering on the north-west European seas have benefited. Prof. Jores, furthermore, expressed his particular gratitude for the way in which Dr. Carruthers had resumed co-operation with Germany after the Second World War, rendering very valuable assistance to German oceanographical institutions. At the end of the ceremony, Dr. Carruthers gave a lecture on present-day problems of oceanography in Great Britain, presenting a clear view of the valuable results achieved by oceanography proper and showing how physical oceanographers can, to a considerable extent, help fishery biologists. In honour of the occasion the German Geophysical Society held a symposium, at which the senior chairman of the Society echoed the thanks paid to Dr. Carruthers for his services to German oceanography, especially in establishing the German Hydrographic Institute. On the previous day, Dr. Carruthers gave a lecture in the Institute of Oceanography, University of Kiel.

National Institute of Sciences of India: New Fellows

AT a meeting of the Council of the National Institute of Sciences of India held at Bangalore on January 1, the following fellows were elected: *Ordinary Fellows:* Prof. R. K. Asundi, professor of physics, Benares Hindu University; Dr. K. P. Basu, head of the Dairy Chemistry Section, Indian Dairy Research Institute, Bangalore; Prof. K. P. Chattopadhyaya, professor and head of the Department of Anthropology, University of Calcutta; Dr. C. R. Das Gupta, head of the Department of Hæmatology, School of Tropical Medicine, Calcutta; Dr. S. Ghosh, lecturer in applied mathematics, University of Calcutta; Lieut.-Colonel S. D. S. Greval, imperial serologist and chemical examiner to the Government of India and professor of serology and immunology, School of Tropical Medicine, Calcutta; S. Gupta, reader in physics, Muslim University, Aligarh; Dr. P. V. K. Iyer, professor of statistics, Indian Council of Agricultural Research, New Delhi; A. N. Khosla, chairman, Central Waterpower, Irrigation and Navigation Commission, New Delhi; Dr. K. B. Lal, entomologist and officer-in-charge, Plant Protection Service, Government of U.P., Kanpur; Prof. Shri Ranjan, professor of botany and dean of the Faculty of Science, University of Allahabad; Prof. S. R. Narayan Rao, professor and head of the Department of Geology, University of Lucknow; K. Sawhney, secretary, Indian Central Cotton Committee, Bombay; Prof. N. K. Sen, professor and head of the Department of Chemistry, Presidency College, Calcutta, and University lecturer in chemistry, Calcutta; Sir M. Visweswaraiya, chairman, All-India Manufacturers Organization, Bangalore. *Honorary Fellows:* Sir Alexander Fleming, professor emeritus of bacteriology, University of London; Prof. R. Kuhn, director, Kaiser Wilhelm Institut für medizinische Chemie, Heidelberg; Prof. H. J. Muller, Department of Zoology, Indiana University; Prof. S. A. Waksman, professor of microbiology, New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick.

State of the Ice in the Arctic Seas

The Danish Meteorological Institute has resumed the publication of its yearly "The State of the Ice in the Arctic Seas", and the issues for 1947 and 1948 have now appeared in the long-familiar style in English (pp. 10+5 maps, 1947; pp. 14+5 maps, 1948; Copenhagen: G. E. C. Gad, 1950). Data are being collected for 1940–45, and it is hoped to publish soon the reports for these years. The year 1947 seems to have been abnormal in several aspects. The ice in the White Sea and more markedly in the Barents Sea had a greater extent than usual. There is a lack of information from Svalbard; but the east coasts were blocked for part of June and in July. More remarkable was the lack of the heavy pack on the east coast of Greenland in the Greenland Current and in Denmark Strait. No ice was reported on the coasts of Iceland. The ice in the south-west of Greenland was exceptionally light. In 1948, data from Svalbard were scanty; but the ice seems to have been more plentiful than usual. June saw a belt of ice on the west coast, from South Cape to Ice Fjord. Data are wanted from the Barents Sea, but, as usual, Franz Josef Land was unapproachable throughout the summer. Most remarkable was the *storis* which came round Cape Farewell into Davis Strait, both late and in small quantities. On the Grand Banks the total amount of field ice was less than usual.

Qualitative Control of Seeds in Great Britain

The committee appointed by the Ministry of Agriculture to consider the possibility of introducing practical methods of qualitative control of seeds used in the United Kingdom has now issued its report (pp. 32; London: H.M. Stationery Office, 1950; 1*s*.). The current Seeds Act and Seeds Regulations naturally form the basis of the discussion, though the aspects considered cover a somewhat wider field, falling into five main groups: list of seeds to be subject to qualitative control; analytical standards in relation to seed-control measures; incidence of disease; encouragement of the use of varieties or strains of proved value; and authenticity and purity of strain and variety. A considerable extension in the list of seeds to be included under the Seeds Regulations is suggested, together with a revision of the limits at and below which the percentages of their purity and germination should be declared. Prohibitive minimal percentages of both factors, below which seeds should not be sold for sowing, are also proposed. The current schedule of injurious weeds is enlarged, and a table showing the potential danger of the inclusion of a small proportion of various weed seeds clearly illustrates the necessity for adequate legislative measures on this matter. Recommendations with regard to seed-borne diseases are the outcome of consultations with an *ad hoc* committee of plant pathologists. The need for the closest co-operation between the seed-testing stations and the plant pathology services is stressed, a first requisite being the development of standard techniques suitable for the detection of potential parasites in seed samples. Since the use of good-quality varieties or strains is fundamental to maximum crop production, the setting-up of a technical committee to advise on this matter is recommended. A list of functions for such a committee is appended, specialist sub-committees being suggested for the consideration of certain aspects, for example, varietal synonyms, seed-borne diseases and seed-testing technique.

Canadian Course on University Lecturing

The National Conference of Canadian Universities has decided to repeat this summer the three-week lecture-giving course for university teachers which was held last June (Hon. Sec., T. H. Matthews, McGill University, Montreal, 2). The programme of this school was essentially practical and was intended to help the teacher in the classroom or laboratory. There were a few short provocative talks by the staff upon topics such as the control of the voice, preparing notes for lectures, student notes, the use of a text-book, setting and marking examination papers, and so on, but most of the talking was done by the 'students', who ranged in rank from a full professor to a junior lecturer. Every student gave at least four talks to the others, who acted as the audience. Some of the talks were introductory lectures in courses the speakers were actually giving in their own universities, others were aimed at outside audiences and included adult-education lectures, radio talks and even a speech to a university senate. The talks were all recorded upon tape machines so that speakers might afterwards hear how they sounded to others and could discuss their performances with the staff and with fellow students. In addition, each student was criticized by his audience immediately after his or her speech, and there was a cheerful atmosphere of give-and-take in these discussions. It was surprising to see how quickly some obviously bad lecturing habits disappeared and how the quality of presentation improved under friendly discussion. Every day there were also special round-table discussions which the students themselves ran and which had some very lively arguments.

Cecil Peace Prize

The Cecil Peace Prize for 1950 has been awarded to Mr. Conrad Ascher, of University College, London, the subject of the essay being "What is meant by the Balance of Power? And has its attempted maintenance since 1660 been useful for Peace or not?" The Prize, which was founded by Viscount Cecil of Chelwood in 1925, is an annual award, worth £100, and is open to all members (less than twenty-five years old) of the universities of the United Kingdom. The subject for 1951 is "The action of the United Nations to put down aggression . . . against the Republic of Korea . . . marked a turning point in history" (Mr. Dean Acheson at Flushing Meadow, September 20, 1950). Essays must be sent in before November 1 to the secretary of the Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1, from whom further conditions relating to the Prize can be obtained.

Laboratory Animals Bureau: Congress in Liverpool

The annual congress of the Laboratory Animals Bureau will be held this year at the University of Liverpool during April 9–10 and will be opened by Sir Henry Cohen, professor of medicine in the University. During the morning of the first day, papers will be read by a number of technicians, and on the second morning a paper by Dr. J. W. Howie, of the Rowett Research Institute; Prof. R. E. Glover, professor of veterinary pathology in the University of Liverpool, will be in the chair. Admission to these sessions of the congress will be confined to invited technicians only. The afternoons will be devoted to visits to local laboratories and animal houses. Over the two days, a trade exhibition will be held at which animal house furnishings, equipment, feeding stuffs, books,

etc., will be exhibited, and technical experts from the exhibiting firms will be present to meet any animal technicians and others concerned with the care and handling of laboratory animals. Admission to this exhibition is not confined to technicians: graduate workers will be welcome. Requests for invitations to the Congress should be addressed to the director of the Laboratory Animals Bureau, Medical Research Council Laboratories, Holly Hill, Hampstead, London, N.W.3.

Exhibition of the Petroleum Industry

An exhibition of the petroleum industry, with emphasis on exploration and on developments in oil-fields, refineries and transport in many parts of the world, will be shown this summer at a number of university centres in Great Britain. The aim of the exhibition is broadly educational in terms of scientific and general university interest, but it is also designed to appeal to the interested layman. It is sponsored by the Shell Petroleum Co., Ltd., and the Anglo-Iranian Oil Co., Ltd. The exhibition will be opened by Sir Henry Tizard under the auspices of the Institute of Petroleum and will be available to the public as follows: April 6–21, Imperial College of Science and Technology, London; May 4–19, Royal Technical College, Glasgow; June 20–July 6, University of Leeds; July 16–28, University of Cambridge.

Colonial Service: Recent Appointments

The following appointments in the Colonial Service have recently been announced: J. Cook (agricultural officer, Federation of Malaya), senior agricultural officer, Federation of Malaya; L. J. S. Littlejohn (soil conservation officer, Cyprus), agricultural officer, Tanganyika; J. P. Edwards (deputy director of forestry, Federation of Malaya), director of forestry, Federation of Malaya; W. A. Miller (assistant conservator of forests, Gold Coast), forest utilization officer, Gold Coast; S. Stock (senior engineer geologist, Development and Reconstruction Authority, Kenya), engineer geologist, Public Works Department, Kenya; E. C. S. Dawe (director of veterinary services, Bechuanaland Protectorate), deputy director of veterinary services, Tanganyika; S. N. Adams, soil chemist, West African Cocoa Research Institute, Gold Coast; A. Barnsley, geologist, Gold Coast; Dr. F. D. Ommanney, principal scientific officer, East African Marine Fisheries Research Survey, East Africa High Commission; Dr. J. F. G. Wheeler, senior principal scientific officer (director), East African Marine Fisheries Research Survey, East Africa High Commission; C. W. Brown, veterinary officer, Kenya; D. T. Graham and W. W. Kirkby, veterinary officers, Nigeria; J. A. R. Anderson, assistant conservator of forests, Sarawak; G. Armitage, G. E. A. Barham and P. V. G. Lang, agricultural survey officers (cocoa), Gold Coast; P. T. W. Baxter, anthropological research officer, Kenya; M. G. Christie, entomologist, Medical Department, Tanganyika; R. Desowitz, laboratory superintendent, West African Institute of Trypanosomiasis Research; B. J. A. Nowosiel-Slepowron, scientific assistant, Tsetse Control, Gold Coast; T. C. E. Thomas, entomologist, Medical Department, Sierra Leone.

Announcements

Prof. John F. Fulton has recently retired from the chair of physiology at Yale University in order to take up a new appointment, also at Yale, as Sterling professor of the history of medicine. Prof. Fulton hopes to develop a small department in the field of the history of medicine and science which will be situated in the historical division of the Yale Medical Library. He also intends to continue research in his old department on certain phases of physiology.

The Warner Medal of the Textile Institute has been awarded to Dr. J. G. Martindale, principal of the Scottish Woollen Technical College, Galashiels, in recognition of his outstanding work in textile science and technology, and particularly for work published in the Institute's *Journal*. Dr. Martindale is the sixteenth recipient of the Medal, which was inaugurated in 1930 to perpetuate the memory of the late Sir Frank Warner, president of the Institute during 1918–19.

Dr. Roger Parsons, of the Imperial College of Science and Technology, has been appointed Junior Deeds Research Fellow in the Chemistry Department, University College, Dundee (University of St. Andrews).

The annual conference of the Education Group of the Institute of Physics will be held at the Institute of Physics, 47 Belgrave Square, London, S.W.1, during April 5–7. A public lecture will be given by Prof. A. M. Tyndall at the Fyvie Hall, Polytechnic, Regent Street, London, W.1, on April 6 at 8 p.m., his subject being "Atomic Particles—a Survey of Recent Discoveries". Attendance at the conference will be limited to about a hundred, preference being given to members of the Institute. Applications for attendance and further details should be addressed to N. Clarke, deputy secretary of the Institute, at the above address.

The London Section of the Oil and Colour Chemists' Association, for the third year in succession, is organizing a technical trade exhibition of raw materials and equipment used in the paint, varnish and printing-ink industries, to be held at the Borough Polytechnic, Borough Road, London, S.E.1, during March 19–21 (2.30–8.30 p.m. each day). Further details can be obtained from the honorary secretary, H. C. Worsdall, c/o Plastanol, Ltd., Crabtree Manor Way, Belvedere, Kent.

The National Association for Mental Health (Maurice Craig House, 39 Queen Anne Street, London, W.1) is holding its annual conference during March 12–13 at the St. Pancras Assembly Rooms, St. Pancras Town Hall, London, N.W.1. The subject of the conference is "Community Mental Health in Practice".

The December 1950 issue of *L'Astronomie* contains a number of communications which will prove useful to amateur astronomers and also some matters of historical interest, such as the Henry brothers' expedition to the Pic du Midi to observe the transit of Venus on December 6, 1882. There is also an account of the discovery on February 19, 1950, by Arend, at the Royal Observatory of Belgium, of the new minor planet belonging to the Trojan group, the period of revolution of which is 11¾ years. There follows a short account of the work of Lagrange on the problem of three bodies and also on the interesting movements of the asteroids of the Trojan group. As usual, the features of the night sky for the second month after the date of issue (for February in the present case) are given together with a table of interesting phenomena.

THE HARWELL TIME-OF-FLIGHT NEUTRON SPECTROMETER

By A. W. MERRISON and E. R. WIBLIN
Atomic Energy Research Establishment, Harwell

IN a recent review of progress at Harwell[1], the installation of a 3·5-MeV. linear electron accelerator was noted. This machine has been installed as a major component of a time-of-flight neutron spectrometer, the operation of which may be briefly described as follows. Neutrons are produced in bursts and detected in groups corresponding to the time elapsing between the generation of a burst and the arrival of the group in the detector. This time corresponds to flight over a known distance, and so the mean velocity and energy of the group may be computed. The neutrons pass through a sample before entering the detector, and the transmission of the sample (and so its total cross-section) may be measured.

Previous papers[2–4] have described the principles on which the accelerator operates and its technical design, while the suggestion as to its possible use as a pulsed neutron source was made by Sir John Cockroft[5].

In the present communication the details of the complete installation are briefly described, including the accelerator, control mechanism, vacuum system, and time-of-flight measuring circuits. Some performance figures are given and compared with those of other spectrometers.

The region of neutron energy below about 10 eV. can be fairly fully explored with crystal monochromating spectrometers operating on beams from nuclear piles. Alternatively, for the same energy region, a time-of-flight system can be operated using mechanically 'chopped' beams from piles to provide the neutron pulses. Above about 20 KeV., measurements are possible with mono-energetic neutrons obtained from (p,n) reactions using high-voltage generators. At the extremes of the region between about 10 eV. and about 20 KeV. the resolution attainable with these machines is poor, and pulsed source/time-of-flight systems are the only ones giving reasonable resolution.

The most prolific source so far of published information in this region is the pulsed cyclotron spectrometer at Columbia University, New York[6].

The Harwell spectrometer is arranged to cover this energy-region, although, with the present accelerator, measurements with reasonable resolution will be only possible up to about 1 KeV. It is hoped to extend this upper limit later by the use of a more powerful accelerator. Approximate figures for resolution and energy of the present Harwell and Columbia spectrometers are given in the accompanying table, together with figures for the mechanical spectrometer in use at the Argonne National Laboratory, Chicago[7].

System	Energy E	Resolution $\Delta E/E$
Columbia spectrometer	1 eV. 10 eV. 100 eV. 1 KeV.	1/16 1/8 1/3 1/1
Argonne mechanical spectrometer	1 eV. 10 eV. 100 eV. 1 KeV.	1/11 1/6 1/2·5 > 1
Harwell 3·2-MeV. linear accelerator spectrometer	1 eV. 10 eV. 100 eV. 1 KeV.	1/9 1/7·5 1/5 1/2

The Accelerator

The corrugated accelerating wave-guide is mounted horizontally in a vacuum envelope supported on a very rigid aluminium structure to preserve its axial alignment. The coils providing the axial focusing magnetic field are mounted independently. The whole assembly is supported on two brick piers inside a concrete and brick radiation shelter.

The system is evacuated by means of two 4-in. diameter oil-diffusion pumps backed by rotary pumps. The operating pressure as indicated by an ionization gauge is about 5×10^{-6} cm. mercury. The vacuum system is controlled from a console inside the shelter, while pressure-indicating meters are repeated on the main control desk situated outside.

Radio-frequency power for the accelerator is provided by a magnetron valve giving pulses of 3,000 Mc./s. radiation of 2 MW. peak-power. The pulses are 2 μsec. long and occur every 1/200 sec. The unit containing the magnetron and its power and drive circuits is placed on the roof of the radiation shelter, and the power is fed, in a rectangular wave-guide, through a small hole in the roof, to the accelerator. The whole unit is remotely controlled from the main control desk.

The electron output of the machine varies with the injected electron current, so that at low current the peak electron energy is 3·6 MeV., while at about 40 microamp. mean current (corresponding to a pulse current of 100 milliamp.) the energy is 3·2 MeV.

The electrons are stopped in a water-cooled platinum target from which the gamma-ray output corresponds to a dose-rate of about 200 r./min. at 1 m. distance.

The predominantly forward gamma-rays are absorbed in a target of beryllium from which neutrons are emitted by photodisintegration. Theoretical estimates of the neutron output obtainable with the given electron output indicated a total mean integrated output of 10^9 per sec. Experiments[8] have confirmed this estimate which, with the pulse of 2 μsec. length and 200 cycles/sec. recurrence frequency, corresponds to a neutron production-rate during the pulse of $2{\cdot}5 \times 10^{12}$ per sec.

The Time-of-Flight Circuits

The fundamental measurement of neutron energy is provided by a crystal oscillator giving timing impulses every 2 μsec. These impulses are used simultaneously to initiate the drive pulses to the accelerator and to open a series of thirty-two electronic gates. These gates sort the pulses from a neutron proportional counter into groups according to their time of arrival in the counter, the time being measured relative to the departure of neutrons from the beryllium source.

The counter is placed at a distance of 10 m. from the source, and collimating tubes are so arranged that neutrons arriving in the counter must have passed through the sample under investigation.

The time-width of the gates may be selected at 2, 10 or 50 μsec. The minimum uncertainty in time measurement is therefore 4 μsec.—which sets the resolution of the instrument at the higher energy

limit. The counting-rate obtainable with no intercepting sample is roughly constant over the energy-range when a boron trifluoride proportional counter is used and, with boron trifluoride enriched in boron-10, is about 4 counts per min. per μsec. of gate-width for a counter of 50 cm. active length, 2½ in. diameter filled to a pressure of 60 cm. mercury.

An improved performance is achieved by the use of an evacuated flight-path tube between source and detector, so eliminating loss of neutrons by scattering in the air. This amounts to about 6 per cent per metre of path.

It is hoped that the boron/scintillation type of neutron counter described by Duckworth, Merrison and Whittaker[9] will be used with the equipment. The resolution at higher energies will then be improved, since greater path-lengths will be possible with the higher efficiency of counting.

The general design of the accelerator has been the work of the Accelerator Group of the General Physics Division, while the time-of-flight circuits were designed by members of the Electronics Division. Both sections were developed jointly with, and manufactured by, the Mullard Electronic Research Laboratories in conjunction with Phillips Electrical, Ltd. Installation has been carried out jointly by Mullards, Electronic and Nuclear Physics staff of the Atomic Energy Research Establishment and the Ministry of Works. Acknowledgment is made of the permission of the Director of the Establishment to publish this article. [Nov. 7.

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UPTAKE OF ANTIBIOTIC METABOLITES OF SOIL MICRO-ORGANISMS BY PLANTS

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AND
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THE discovery of a zone of increased micro-biological activity in the soil adjacent to plant roots, known as the rhizosphere, has led in recent years to one of the most fruitful lines of research in the field of soil microbiology. Three main processes have been visualized in the complex and intimate relationships between the micro-organisms of the rhizosphere and the plant root: (*a*) encouragement of a microflora greater in numbers than and qualitatively different from that of the soil more distant from the roots, as a result of excretion of soluble nutrients and sloughing-off of dead tissue by the roots; (*b*) intensified antagonistic and associative interactions between groups of micro-organisms in the rhizosphere consequent upon the higher level of microbiological activity; (*c*) beneficial or detrimental effects on the development of the roots (and hence of the whole plant) as a result of activity of the rhizosphere organisms. Much experimental work has been devoted to the effect of the root on the microflora and on the relations between different groups in the microflora. The effect of rhizosphere organisms on the plant has received less attention, except in the somewhat special cases of mycorrhizal fungi, root-nodule bacteria and fungal root parasites. It has been suggested that metabolites of the saprophytic rhizosphere such as vitamins, auxins or other growth factors may affect the development of plant roots; this has not as yet been unequivocally supported by experiment, though recent work[1,2] has shown that certain organic substances are needed for optimum development of some plants.

Among the micro-organisms commonly found in the rhizosphere are species of bacteria[3], actinomycetes[4] and fungi[5,6] capable of producing antibiotics under certain conditions of culture. It is not yet known whether micro-organisms can produce antibiotics in soil; but in some cases the antagonistic powers of an organism, the fungus *Trichoderma viride*, for example, appear to be strongly associated with the potentiality for producing antibiotic metabolic products. The most likely loci for the production of antibiotics under soil conditions are the rhizosphere and the vicinity of particles of energy-yielding decomposable matter. It seemed possible to us that, if antibiotics are produced by micro-organisms in the rhizosphere, they may have a direct effect on plant roots as well as on the neighbouring micro-organisms and may affect not only plant roots but also, if translocated, have important consequences for the aerial parts of the plant as well. Certain experiments based on this line of thought have yielded results which seem to us to be of sufficient general interest to warrant the publication of a brief account, even at this preliminary stage of the investigation.

The work described here has been carried out with the antibiotic griseofulvin. We were influenced by four considerations in choosing this substance for study. (1) It can be detected specifically and in low concentration by a bioassay based on its unique effect on the morphogenesis of some fungi. (2) It is stable in aqueous solutions and more stable than many other antibiotics in soil; though biological degradation takes place in a neutral loam, in sterile soil and certain acid soils it is remarkably persistent[7]. (3) Though toxic to higher plants[8], it is much less toxic than other antibiotics of which we have experience. (4) It is produced by a fungus, *Penicillium nigricans* (Bainier) Thom (= *P. janczewskii* Zal.), which is abundant and widely distributed in natural and agricultural soils[9,10], as well as by the less common *P. griseofulvum* Dierckx (= *P. urticæ* Bainier).

Uptake and Translocation of Griseofulvin

Preliminary experiments with several plant species showed that, if cut shoots were placed with the cut end immersed in an aqueous solution of griseofulvin (10 or 100 μgm./ml.), griseofulvin could be detected in the upper leaves in 7–14 days. Experiments were therefore undertaken to determine whether it could be taken up by plants through the root system.

Lettuce seedlings were raised in water-culture in beakers, using a modified Pfeffer solution. When the seedlings were well established, the nutrient was

removed and replaced by similar solutions containing griseofulvin; controls received normal nutrient solution only. When examined four weeks later, seedlings grown in 10-μgm./ml. griseofulvin showed root-stunting but little other damage; those grown in 50-μgm./ml. griseofulvin were stunted both in root and shoot as compared with controls. Leaves were ground with a little distilled water, and the filtrate assayed for griseofulvin; it was detected in leaves from plants grown in griseofulvin, but not in leaves from control plants.

Oat seedlings were raised in water-culture in a cool greenhouse. Again, when the seedlings were established, the nutrient was replaced, either by nutrient containing griseofulvin at 10 or 50 μgm./ml. or by unsupplemented nutrient. Production of guttation-drops was encouraged by enclosing the plants overnight in a bell-jar; samples of the guttation-fluid were collected and assayed for griseofulvin. (A similar technique has been used by Frohberger[11] in studies of the translocation of systemic insecticides.) It was found expedient to dilute guttation-fluid before assay with an equal quantity of a nutrient 'germination-medium'[12] adjusted to *p*H 3·5; this prevented rapid multiplication of bacteria and ciliate Protozoa present in the guttation-fluid, which otherwise interfered with normal development of the assay test-fungus, *Botrytis allii*. Seven days after placing the plants in the griseofulvin solutions, of either concentration, griseofulvin could be detected in the guttation-fluid in a concentration of 0·1–1·0 μgm./ml.; in the controls none was found. This finding was confirmed on the eighth, ninth and fifteenth days. The nutrient was then removed, the roots gently washed, and fresh nutrient containing no griseofulvin added. Griseofulvin continued to appear in guttation-drops for a further three to four weeks from the plants which had formerly been grown in the griseofulvin solutions, indicating that some storage had taken place. Plants which had received griseofulvin were stunted and, in the later stages of the experiment, developed severe 'tip-burn' of the leaves. A similar experiment was carried out with oat seedlings grown in soil, to which griseofulvin was added by watering with a 50-μgm./ml. solution after the seedlings were established. Again griseofulvin appeared in the guttation-drops, though less rapidly than in water-culture.

There seems to be no doubt that griseofulvin can be taken into plants through the root system and can thence be translocated to the leaves.

Griseofulvin as a Systemic Protectant against Fungus Attack

Griseofulvin has marked fungistatic properties, though it is never fungicidal in the strict sense. We were naturally led to consider whether introduction of griseofulvin into a growing plant would confer resistance to fungal parasites. In a preliminary experiment, lettuce seedlings were raised in water-culture and the nutrient was replaced by griseofulvin-containing nutrient when the seedlings were well established. The plants were sprayed with a suspension of spores of *Botrytis cinerea* (isolated from diseased lettuce) eight and fourteen days after transfer to griseofulvin solutions, the plants being kept in a humid atmosphere for forty-eight hours after each inoculation. Disease developed slowly at first, but four weeks after inoculation it became clear hat infection was spreading rapidly in control ultures but much less rapidly in the plants grown in 10-μgm./ml. or 20-μgm./ml, griseofulvin. Two weeks later all control plants were infected, most being dead; but at least sixty per cent of the treated plants were free of *Botrytis* infection.

This encouraging result led us to undertake experiments with a more exact technique at the Hawthorndale Laboratories, using *Alternaria solani* on tomatoes. In these experiments, potted tomato plants, variety Best of All, were grown in sand culture. Treated plants were watered daily for four days with 50 ml. of either a dispersion or a solution of griseofulvin while control plants received tap water. Both series of plants were also given an additional daily watering with 50 ml. of culture solution. Three replicate plants were used for each treatment. On the fifth day the plants were inoculated with an aqueous suspension of spores of *A. solani* (25×10^3 spores/ml.). This spore suspension was applied with a simple right-angle jet atomizer operating at 3 lb./sq. in. air pressure, the plants being held in the hand while a uniform spray coverage was applied to the lower leaf surfaces. The plants were then kept in a humidity cabinet at 98–100 per cent relative humidity for twenty-four hours before being returned to the greenhouse. The number of lesions produced on the twenty-five main leaflets of the lower five leaves of each plant were counted two days later.

In the initial experiments, using a 500-μgm./ml. suspension of griseofulvin in 2 per cent aqueous acetone, only small water-soaked pin-points of infection, discernible with difficulty, developed on the plants treated with griseofulvin. The control plants, on the other hand, showed an average of 1,250 normal, brown, somewhat angular lesions. The experiment was repeated three times with a similar result. Following the lesion count in the third test, the treated plants were returned to the greenhouse for a further week. During this period there was no further development of the initial points of infection. The plants were then repotted in fresh sand and four days later were reinoculated with *A. solani*. Following this second inoculation, normal lesions developed. Thus the period of complete protection given by griseofulvin treatment was less than fourteen days.

Finally, using the method already described, but watering with a 100-μgm./ml. solution of griseofulvin, it was found that some normal lesions did develop on the treated plants, but that the griseofulvin gave 74 per cent control of the disease; details of the lesion counts are given in Table 1. Under these conditions, none of the griseofulvin treatments affected the vigour of the plants.

Table 1

	Replicate lesion counts: A	B	C	Total lesions	Disease (per cent)	Disease control (per cent)
Griseofulvin	127	486	133	764	26	74
Control	775	880	1,289	2,944	100	0

We conclude that griseofulvin shows undoubted activity as a systemic 'fungicide'; similar activity has recently been demonstrated for certain aryloxy-aliphatic acids[13] and 4-nitrosopyrazoles[14].

Production of Griseofulvin in Soil

In all the experiments so far described, solutions of pure griseofulvin were added to the soil or nutrient solution. Experiments designed to determine whether griseofulvin could be produced by microbiological synthesis in the soil, and then pass into plants, have been inconclusive.

Penicillium griseofulvum was grown for fourteen days on sterile soil enriched with 2 per cent wheat-

meal. This was used to inoculate both heat-sterilized and untreated loam-soil at inoculum-rates of 2, 20 and 80 per cent on a dry weight basis. Oats were sown in four replicate pots of each of these treatments and in uninoculated sterile and in unsterile soil. As soon as the seedlings were large enough, guttation-drops were collected and assayed for griseofulvin. The estimated quantity (μgm./ml.) of griseofulvin present on a number of occasions is shown in Table 2.

Table 2

Days after sowing	2 per cent inoculum		20 per cent inoculum		80 per cent inoculum	
	U*	S†	U	S	U	S
16	—	0·2	0·1	0·4	0·4	0·4
21	0·1	0·1	0·2	3·0	1·6	0·8
23	0·1	0·1	0·1	3·0	0·8	0·8
28	—	—	—	6·0	6·0	6·0
30	—	—	—	3·0	0·8	3·0
35	—	—	—	0·4	0·4	3·0

* untreated loam-soil. † heat-sterilized loam-soil

Griseofulvin appeared in the guttation-drops from plants grown in all inoculated soils, but not in controls. The amount present was roughly related to the size of the inoculum; but inocula were always more effective in sterile than in unsterile soil. Growth was severely retarded by the heavier inocula in sterile soil, but only slightly in unsterile soil. We believe that this difference is due to biological degradation of griseofulvin in unsterile soil. Taken at their face value, these results would appear to indicate that inoculation of soil by a griseofulvin-producing mould does result in griseofulvin entering plants grown in the soil. However, it was found that the inoculum itself contained griseofulvin; griseofulvin appearing in guttation-drops might therefore have been biosynthesized before the inoculum was added to the soil in which the plants were grown. That this was what happened was strongly suggested by a further experiment using a *P. nigricans* inoculum. In this case, heat-killed inocula were also used and were found to be as effective as the live inocula.

The establishment of a sufficiently active population of *P. nigricans* or *P. griseofulvum* to secure production of griseofulvin in a normal soil is bound to be more difficult than in sterile soil. Nevertheless, much more experimental work must be carried out before the possibility can be discarded. Our results do indicate, however, that it is not necessary to use pure griseofulvin to secure its systemic distribution in plants but that a crude soil/cornmeal or similar culture of *P. nigricans* or *P. griseofulvum* may be used.

These results refer to one substance only—griseofulvin. On general grounds it seems likely that equally interesting results might be obtained with others of the numerous antifungal metabolic products of moulds now known.

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GROWTH OF SINGLE CRYSTALS OF TIN FROM THE MELT

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FOR the examination of the fundamental physical properties of metals, specimens in the form of large uniform single crystals are most useful, and methods for their growth are now well known[1]. Since its introduction by Andrade[2] in 1914, the method of growth by solidification of the metal, under conditions of slow cooling, from the liquid state has been much used, and the successful growth of single crystals of a large number of pure metallic elements has been reported. The experimental arrangements and conditions which were found to be necessary, or best suited for, the production of the crystals have been noted by several investigators; but these consist mainly of scattered and uncorrelated observations. The purity of the metal; the temperature gradient, G, in the specimen; and the speed, R, of growth of the single crystal appear to be controlling factors; but a detailed examination of the literature revealed considerable disagreement as to the influence of these factors on the growth. In addition, no systematic investigation of the influence of G and R on the growth could be found for any metal. To remedy this defect, experiments have been carried out on tin, and it is hoped to extend them in the near future to other metals.

108 rods of tin, 15–25 cm. in length, were crystallized from the melt under various controlled conditions of temperature gradient and rate of growth, and the resultant crystalline structures were examined. The travelling furnace method of Andrade and Roscoe[3] was used with various speeds of travel between 0·5 and 20 mm./min. The temperature gradient in the metal at the melting point was varied for each speed over as wide a range as possible. The metal, supplied in one batch by Messrs. Johnson, Matthey and Co., Ltd., was stated to be 99·997 per cent pure, the main impurities being lead (0·0012 per cent) and antimony (0·001 per cent). It was cleaned by melting and filtering it *in vacuo* through a 'Pyrex' glass capillary. The metal was then outgassed and cast into 5-mm. diameter rods of 15–25 cm. length. Four rods, each in an open 'Pyrex' tube of 7 mm. internal bore, and a fifth similar rod (dummy specimen) but with an embedded thermocouple for temperature measurement, were placed together in the furnace tube. All five rods were similarly placed with respect to the travelling furnace and this moved horizontally, at a speed controlled by a synchronous motor, over the furnace tube. A moderate vacuum of about 0·01 mm. mercury pressure was maintained in the tube. The temperature of the rods, determined by the thermocouple in the dummy specimen, was recorded continuously on a Kent potentiometric recorder and was correct to within 1° C. The various speeds of travel and temperature gradients used are shown in the accompanying table.

Speeds of growth (mm./min.)		Percentage of 'successful' crystals	Percentage of fibrous crystals	Ranges of temperature gradient (° C./cm.)
Very fast	20	100	0	11–13
Fast	10	70	20	8–10
Medium	5	42	50	9–19
Slow	1·5	67	13	10–28
Very slow	0·5	96	4	10–35

The rods, after crystallization, were carefully examined and any imperfections were noted. The rods were also chemically etched and a sketch made of the visible crystalline structure. Each rod was then mounted vertically in a specially designed goniometer and the orientation of the cylindrical axis of the rod relative to the axes of the single or poly-crystals in the rod determined by the optical method used by Chalmers[4]. The goniometer was constructed in such a way that the rod, when mounted, could not only be rotated but also moved vertically, and the spot pattern corresponding to any point along the rod examined in detail. Thus any variation in the crystalline structure could be detected immediately and measured.

In general, the crystalline formation was found to consist of two distinct parts. The end of the rod where solidification first commenced was poly-crystalline, and this extended for a few centimetres along the rod, the smallest grains being at the end of the rod. For the low speeds of travel, however, this end of the rod was often a single crystal but of different orientation from that of the rest of the rod. (It is known from our previous experiments that supercooling occurs during the crystallization of the first few centimetres of the specimens.) The remainder of the rod, that is, apart from the first few centimetres, was usually a single crystal. For the very fast and the very slow (20 and 0·5 mm./min. respectively) speeds of travel, optically perfect single crystals were produced. These are crystals for which no variation in orientation, or multiplicity in the spot pattern along the rod, could be detected on the optical goniometer.

In the single-crystal portion of the rods, the three main imperfections observed were: (i) small crystal inserts of various other orientations; (ii) possibly several distinct crystals, and often a bi-crystal with a long boundary parallel to the length of the rod (fast, medium and slow speeds all show this type of imperfection); and (iii) a macromosaic structure in the form of fibres, that is, strips, about 1 mm. wide, of crystals of slightly differing orientations.

The forms of crystals obtained for the various speeds and temperature gradients are listed in the table. A crystal was classified as 'successful' when 10 cm. or more of the rod was found to be of one predominant single-crystal structure. In all, fifty-four separate tin rods were used and each was crystallized twice.

When the orientations of the axes of the single crystals relative to the rod axes for the various specimens were plotted in stereographic projection, it was seen that, for the crystals grown at speeds of 5 mm./min. or less, the angle between the rod axis and the *c*-axis of the crystal was always 70–90°. For higher speeds there was a larger scatter of values. It should be noted, in addition, as is shown in the table, that the least number of successful crystals and the most failures due to fibrous mosaic structure occur at the limiting speed of 5 mm./min. It is suggested that the reason for the preference of the crystal orientation for the 110 direction is the marked anisotropy of tin, and the corresponding difference in values of the thermal conductivity, thermal expansion and elastic modulus, in particular, in the 110 direction from their values in other directions.

From the results there does not appear to be any relation between the temperature gradient, or the ratio of this gradient to the rate of crystal growth, G/R, and the resultant crystal orientation. The directions of the *c*-axis are also randomly orientated relative to the upper surfaces of the rods.

The cooling-curve records were also examined, and it is interesting to note that for the speed of 5 mm./min. no break occurred in the cooling curve at the solidification point.

It is hoped to publish elsewhere a more detailed account of the experimental work and a fuller discussion of the results.

We are indebted to Prof. A. M. Taylor and the College authorities for facilities provided, and one of us (A. J. G.) to the Ministry of Education for a Further Education and Training grant.

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EXPERIMENTAL AND RESEARCH STATION, CHESHUNT

ANNUAL REPORT FOR 1949

THE experimental and research station of the Nursery and Market Garden Industries' Development Society, Ltd., at Cheshunt, Herts, is now rather congested, and the glasshouses still show the effects of enemy action during the Second World War. Results of the work continue their steady progress, however, and the annual report for 1949* includes a number of detailed reports on current research. Alginates have been used as sources of organic matter in the cultivation of tomatoes. Sodium alginate, at 1 oz. per sq. yd., gave yields almost as good as farmyard manure, and well over those of the control plots; calcium alginate and milled seaweed had little effect. Among varieties, Corleys, Downes Seedling, Bruinsma and Auchincruive 1*a* and 5 were the heaviest croppers.

P. H. Williams reports on the effects of various environmental and edaphic factors on the rate of growth of *Didymella lycopersici*. This fungus, though a parasite, can nevertheless grow saprophytically over a wide range in soil moisture conditions; it grows, for example, faster in soil with added stable manure than in the well-rotted organic matter of an old cucumber bed. On culture media, tomato juice, wheat straw extract, and biotin (vitamin B_8) stimulated growth. It is now obvious that *D. lycopersici* can grow as a saprophyte under widely varying conditions and nutrition, thus constituting an ever-present source of danger to the tomato crop. The same author finds that the American tomato variety Essar has proved resistant to *Verticillium* wilt. Marion Ebben has studied a brown root rot of tomato, with which several fungi appear to be associated. Smoking tobacco is known as a source of tobacco mosaic on the tomato, and R. Howles reiterates this danger. He also finds that spraying with 1 per cent tannic acid once a week considerably delays the spread of aucuba mosaic between tomato plants by contact, that an anti-virus paste on the hands and knife reduces transmission during handling, and that treatment of virus-infected tomato seed with 400,000 rœntgens of X-rays did not inactivate the virus.

* Experimental and Research Station, Cheshunt. Annual Report (thirty-fifth Year), 1949. Pp. 80+6 plates. (Cheshunt: Nursery and Market Garden Industries' Development Society, 1950.)

Erna Grossbard shows that an antibiotic substance is produced by *Penicillium patulum* on sterilized soil to which a source of carbohydrate is added. *Aspergillus terreus* produced a less-effective antibiotic under similar conditions. One result of probable significance in practice is that *Streptomyces griseus* antagonizes *Phytophthora parasitica*, a parasite of tomato seedlings and roots.

A detailed paper by E. R. Speyer and W. J. Parr gives the life-history and control of the tomato leaf-miner, *Liriomyza solani*. They discuss control at the seedling stage by DDT and gamma-benzene hexachloride, the effect of nicotine upon the larvæ, and of pyrethrum powder upon the adult flies. A series of tests of various insecticides in the laboratory and greenhouse has been made by W. H. Read. They include results from systemic insecticides and indicate that *bis* (*bis*-dimethylamino) phosphonous anhydride, though poisonous, is very promising for the control of aphids or red spider on carnations.

Chemical researches include nitrification studies by G. W. Winsor, steam sterilization studies by O. Owen and J. N. Davies, and the tabulation of mineral deficiencies, mostly on chrysanthemums. This is all long-term work, and the final results should be as interesting and illuminating as are earlier results from this section.

WATER POLLUTION RESEARCH BOARD

ANNUAL REPORT FOR 1949

THE Water Pollution Research Board is the body coming under the Department of Scientific and Industrial Research, which is responsible for research on water pollution in Great Britain. Mr. H. W. Cremer is chairman of the Board, and Dr. A. B. Southgate is director of the Research Laboratory, situated in Watford. One of the functions of the Board is to give friendly advice to any who are perplexed with problems of water pollution; the report for 1949*, which gives a synopsis of its recent activities, affords abundant evidence of this and shows that help is not confined to the British Isles. Where a problem presents features of special interest or importance, the Board sends its research officers to carry out *ad hoc* experiments and extend these to the stage of the pilot plant.

The city of Tehran draws the bulk of its water supply from the River Karaj, and the Board reports that this supply can be made safe by sedimentation with ferric chloride in upward-flow tanks of the sludge-blanket type, followed by filtration through rapid filters which are not seriously clogged by this coagulant. Sterilization with chlorine follows, and the treated water contains only the merest trace of iron. The details of these experiments will prove useful in many tropical lands.

Luton has an urgent problem in sewage purification, for the growth of industry and population has outstripped the capacity of the purification plant, as is the case in so many towns to-day. The effluent passes to the River Lea not far from the headwaters, and the flow of the river has become depleted in recent years because of heavy pumping from the chalk of the Chilterns. With the interaction of these events, the effluent from Luton forms too large a proportion of the flow below the town. This and other risks developing on the river and its tributaries below Luton throw weight on to the Metropolitan Water Board and tend to spoil what was not so long ago one of the loveliest rivers in England. The operation of filters and microstrainers designed to trap the humus from the final effluent is described in this report. Either device removes the humus to a high degree, but filtration seems to be rather more efficient in this regard and definitely more efficient in reducing the biochemical oxygen demand. As a filtering medium sand remains more stable in its grading than powdered anthracite, which tends to fragment in use.

A large part of the report is devoted to a description of the research carried out at the Board's Minworth (Birmingham) Laboratory. The well-known experiments with alternating double filtration of sewage, designed to prevent filter clogging where the sewage is very strong, have been extended, and various combinations of filtering methods are being tested in eight small-scale filters. Serial increase in dosing from the customary low rates up to 1,000 gallons per cubic yard per day are yielding information about the rapid rates of filtration that have become so much the vogue in the United States.

Anxiety about excess breeding of the sewage filter flies *Psychoda* and *Anisopus* has become negligible. It is shown that the addition of 'Gammexane' at the rate of 1 lb. per acre given in dispersible powder to the settled sewage is effective in reducing the emerging flies below annoyance-level. It is not necessary to stop the flow after the application, and this is a great advantage in fully loaded plants. The dose should be kept to the effective minimum, as the working of the larvæ is essential to keep the filters open and a residuum must be left for this purpose. The 'Gammexane' is largely adsorbed by filter film and humus, so that only a negligible amount reaches the river. The humus is frequently mixed with primary sludge and digested anaerobically, so the question has arisen whether the adsorbed 'Gammexane' would interfere with this process. No such harm can result, as only a relatively enormous dose will hamper digestion.

Other topics dealt with in this interesting report concern the stabilization of spent gas liquor by biological filtration, the effect of sewage works treatment on the numbers and types of bacteria, and the treatment of waste water discharged by a paper mill producing a special type of paper from rags and jute. A survey of the Thames Estuary to assess the effects of pollution has been started. The river water is saturated with dissolved oxygen at Teddington and supersaturated at Southend; but from Hammersmith to Tilbury Landing Stage the oxygen value is exceedingly low, conditions indicate anaerobic processes, and gases such as methane and hydrogen sulphide tend to be evolved. Some details of the river bed are also given, and these show conditions better than might have been expected, for it is not until seaward of Barking that extensive deposits of black mud are found.

The Rivers Pollution Prevention Bill now under consideration provides that river boards should be able to prescribe standards with which effluents discharged to a stream, or in some cases to tidal waters, must comply. These standards are to vary with local circumstances, for in some cases a very high degree of purity will be required, while in others

* Department of Scientific and Industrial Research. Report of the Water Pollution Research Board, with the Report of the Director of Water Pollution Research, for the Year 1949. Pp. iv+48+4 pl. (London: H.M. Stationery Office, 1950.) 1s. 6d. net.

it is necessary only to remove the solids from the sewage. Intermediate standards will no doubt be expected in the most highly industrialized areas, for the rivers in such regions will always remain the drains of the economy. The costs of reducing the strongest sewages, such as flow from Bradford and Huddersfield, to the highest standard of purity would form far too heavy a charge on the local rates. Before such varied standards could be prescribed, tests would have to be devised for differing conditions. The Water Pollution Research Laboratory is represented on the committee that has been formed to advise on the formulation of these tests.

Ll. Lloyd

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH OF NEW ZEALAND

ANNUAL REPORT

THE twenty-fourth annual report of the Department of Scientific and Industrial Research, Dominion of New Zealand*, includes the Minister's statement, the Secretary's report and the reports from the various branches, research committees, etc. The Secretary's report refers to the disappointing results which have so far attended efforts to improve the accommodation conditions. Inordinately high building-costs and the shortage of skilled labour have accentuated the difficulties, and the unsatisfactory conditions are markedly affecting the efficiency of certain branches, conditions being particularly bad in the Dominion Laboratory, Grasslands Division, Geological Survey, Soil Bureau and Botany Division. Recruitment of staff has accordingly been kept to a minimum, though attention has been given to the introduction of a scheme of assessing scientific ability and effectiveness and of relating this to promotion. No progress has been made with the establishment of an organization to deal with building and civil-engineering research; but a small Meat Research Section has been established in the Dominion Laboratory. The increased interest in research associations for the manufacturing industries has been a feature of the year.

The Agronomy Division has achieved notable successes with the introduction or breeding of disease-resistant varieties, including the following: rape resistant to club-root; R_1 (Stakhanovetz) linen flax and Cheyenne linseed which are both resistant to the New Zealand strains of flax rust; Achilles oats, an Algerian type which is resistant to leaf-rust and stem-rust; and Calder swede, which is strongly resistant to aphis attack and to turnip-mosaic and moderately resistant to dry-rot, club-root and mottled heart. A survey of vegetable crops has shown that there is great variation of type within strains and varieties of commercial seed, especially among the brassicas, and that some considerable improvement can be effected by careful selection. The recently established chemical laboratory is evaluating different varieties of potatoes in respect of vitamin C and in measuring the extent to which different varieties retain the vitamin on prolonged storage. In the Animal Ecology Section the two major investigations are, first, a study of the biology of the rabbit with the aim of providing basic information for improved control measures, and, secondly, a survey of the mammal and bird fauna of New Zealand.

The Auckland Industrial Development Laboratories were finally established during the year, and the newspaper-wrapping machine has attracted considerable interest. The Electrical Standardization Laboratory has now been established, and in the Engineering Design Section an experimental water-sampling device has been developed. The importance of the herbarium in the Botany Division is increasing, while the Plant Introduction Service has handled 249 out of 620 recorded introductions. Intensive investigations on yellow-leaf disease are continuing at the Moutoa Phormium Research Station. In the Dominion Laboratory the study of the New Zealand grown pines, *Pinus radiata*, *P. laricio* and *P. murrayana*, was continued, including the determination of the distribution of resinous extractives, and assistance was given in the smelting of Patea iron-sands at Onekake by the Department of Industries and Commerce. Work on the curing of tobacco leaf was continued, and analyses made of many samples of spraying-materials.

In the Dominion Physical Laboratory work was carried out on the thermal insulation of buildings, the efficiency of domestic open-hearth fires, the physical properties of *P. radiata*, solar and sky radiation at the surface of the earth, the electrical conductivities of New Zealand soils, and the vibrations of engineering structures. An experimental model of a new type of fractionating molecular still has been built, and apparatus is being developed for supplying plants with artificial sunlight when growing in enclosed cabinets. The amount of external servicing for industry considerably decreased; the investigation of anomalous propagation of radio-waves under north-west wind conditions in Canterbury was completed, and modifications made to the vehicle-speed indicator have increased its accuracy and operational range.

The Fats Research Laboratory, in collaboration with the Dairy Research Institute, has directed its main attention to the elucidation of the nature of butter-fat; but increasing emphasis is being placed on meat fats as part of the New Zealand contribution towards collaborative British Commonwealth work on meat. At the Fruit Research Station field trials are in progress to diagnose a number of fruit-tree diseases suspected of being due to mineral deficiencies, and attempts are being made to develop standard biological tests for the synthetic plant hormones used for setting tomato fruits and for preventing pre-harvest drop of apples. The Geological Survey has been fully taxed by increasing requests for information and guidance on the availability and development of raw materials required by industry, on problems of water-supply, and economic and engineering geology, in addition to the systematic regional mapping and investigation of New Zealand coalfields. Data from the Geophysical Observatory, Christchurch, have proved to be of special importance to international organizations in geophysics, while at the Geophysical Observatory, Wellington, a relation has been established between the 'age' of the moon and the variation of tidal phase differences between Island Bay and Makara.

The Grasslands Division has maintained and improved by further breeding the standard of the pedigree strains of pasture plants, and a study of the

* New Zealand. Twenty-fourth Annual Report of the Department of Scientific and Industrial Research. Pp. 112. (Wellington: Government Printer, 1950.) 2s. 6d.

influence of grazing management on clover establishment emphasized the need for grazing fairly closely for the first six months after autumn sowing. The new pasture, hay and dual-purpose cocksfoot, bred at Palmerston North, have proved over four years to yield about 15 per cent more feed than the Government stock-strain. The Magnetic Survey has prepared and published a navigation chart for the whole of New Zealand and has sent bulletins of earthquake records weekly by air mail to the United States, Strasbourg, Trieste, Rome and Apia. The Occupational Psychology Research Section has been conducting a survey aimed at evolving improved methods for recruiting, selecting and training scientific research workers, and at the request of the Navy and Air Departments a common aptitude test is being applied to all national-service recruits who express a preference for the Navy or Air Force, and by the Army to all regular-engagement recruits.

In the Plant Chemistry Laboratory, use of a staining technique has made possible the reliable determination in twenty-four hours of germinating capacity of rye-grass as against 9–12 days by the standard methods. Further work has been done on the rate of breakdown of urea in herbivorous urine in the soil and on the effect of fertilization with nitrate, ammonia and urea, with the object of determining the way in which they are transformed into leaf proteins. The Plant Diseases Division has confirmed the resistance to leaf-mould of the variety Improved Bay State tomato and has conducted a field survey to determine the relative importance of different pea diseases. Established techniques of bio-assay of fungicides have been extended to include assays under artificial rain; in orchard trials dichloronaphthoquinone gave the best control of brown-rot of peaches, sprays based on phenylmercuriammonium lactate and phenylmercurichloride gave better control of black spot of apples and less foliage injury than standard sulphur sprays, dichlorodiethyl dichloroethane gave highly effective control of leaf roller on apples, and 'Gammexane' outstanding control of woolly aphis.

The Soil Bureau completed the collection of data for the extended legend to accompany the North Island soil maps; South Island has been covered by the reconnaissance survey, and a survey has been made of the soils of Niue Island. Since April 1, 1950, the wheat-breeding section of the Wheat Research Institute has been amalgamated with the former Agronomy Division under the title Crop Research Division, while the cereal chemistry, milling and baking laboratories are continuing their functions under the title of Wheat Research Institute. A disease survey in Waimea County by the Cawthron Institute has confirmed that the most prevalent disease is black root-rot (*Phytophthora* sp.), and promising results have been obtained in its control by soil treatment with DD. Other work at the Cawthron Institute has been concerned with the magnesium deficiency of apples and the effect of zinc sprays on Gravenstein, Sturmer and Jonathan apples on the Moutere Hills soil, the cause of 'die-back' in raspberry canes, the intake of plant nutrients by glasshouse tomato-plants, the effect of heavy applications of potash on the quality of tomatoes and the effect of steam treatment of the soil and of soil disinfectants on the yield of tomatoes. The Dairy Research Institute has completed a survey of the vitamin A potency of butter, and has continued to act as the main source of supply of starters to cheese factories throughout New Zealand. Work was also carried out on the effect of temperature treatment of cream on the body of butter and on the effect of cultures of lactobacilli on cheese flavour.

At the Canterbury Agricultural College, besides a study of the solubility of South Island limestones in the soil, results are reported of progeny testing, fertilizer treatment of pastures on light land, soil fertilizing and investigations into the lameness following dipping in powders containing rotenone and benzene hexachloride are recorded. Work at the Massey Agricultural College includes a manurial trial under rotational grazing, sheep husbandry research, a study of the milk-yield of Romney ewes and of nematode parasitism in sheep, propagation research and farm drainage.

TERRAMYCIN

THE successful use of antibiotic substances against human disease is one of the most fascinating developments of modern medical science. Seven such substances are now commercially available, and one recent introduction—terramycin—formed the subject of a recent conference under the auspices of the New York Academy of Sciences*.

Terramycin shares with aureomycin and chloromycetin a bacteriostatic action against a considerable number of Gram-positive and Gram-negative organisms, gonococci and meningococci; but these three substances are also effective against Rickettsiæ and large viruses. They are not active against tubercle bacilli. The present report results from the collaboration of some eighty-five contributors; it is monumental in execution and comprehensive in scope. Its thirty papers represent such a wealth of detail that the purpose of a review can best be served by indicating the range of subjects covered.

Obtained from the actinomycete *Streptomyces rimosus*, a soil organism, terramycin is prepared as a crystalline substance, the chemical and physical properties of which are described in detail and illustrated in colour. Pharmacology in experimental animals and in man is discussed, as are also its range of antibiotic activity and its clinical action. A considerable part of the report collects information on the action of terramycin against human diseases, and this part has been summarized by Chester S. Keefer, the chairman of the conference. Those diseases in which positive action is recorded include pneumococcic pneumonia, rickettsial diseases, brucellosis and some venereal diseases. Terramycin appears to be ineffective against infections of *Pseudomonas aeruginosa* and *Bacillus proteus*; and of virus diseases, mumps, measles, chicken-pox and smallpox do not respond to its treatment. There is also an intermediate group of diseases, where further information is necessary before terramycin treatment can be recommended.

Terramycin is only a very recent discovery from the biochemical research laboratories of Chas. Pfizer and Co., Inc. It was found as the result of a carefully planned research programme involving the examination of micro-organisms from soil in various parts of the world. The present imposing report of available information reflects a very speedy reaction to its implications within the medical profession.

* Terramycin. By C. S. Keefer, J. H. Kane and 83 other Authors. *Ann. N. Y. Acad. Sci.*, **53**, art. 2, pp. 221–460. (New York: New York Academy of Sciences, 1950.) 3 dollars.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Effect of Pressure on the Behaviour of Decapod Larvæ (Crustacea)

In an account of experiments with the copepod *Calanus finmarchicus* (Gunn.), Hardy and Paton[1] suggested that the behaviour in vertical migration of this and perhaps other plankton animals might be influenced by the differences in pressure at various depths. The following experiments have been made to test this hypothesis. Two vertical 'Perspex' tubes, each 20 in. tall and having an internal rectangular cross-section of 2 in. × 1½ in., were placed side by side. After filling with sea water, experimental animals were introduced and each tube was closed by a flanged, water-tight, 'Perspex' lid (tightly screwed down), and the pressure in one, called the experimental tube, was varied while that in the other, the control tube, was kept at zero. The pressure in the former was changed by raising or lowering a column of mercury which communicated with the tube through a freshwater buffer and a rubber diaphragm, designed to prevent contamination of the sea water by poisons from the mercury. The pressure was measured either by the height of the mercury column or by the level of the meniscus in a manometer and was recorded in terms of 'metres depth of water' equivalent to the number of atmospheres of pressure found.

Freshly caught plankton animals having been put in equal numbers into both tubes, the number found swimming in the upper half of each was recorded at intervals of 15 or 30 minutes, while the pressure in the one tube was varied according to the nature of the experiment. In order to eliminate the effect of light, the experiments were made in a dark room and the animals counted by looking at their silhouettes against a screen illuminated by a red lamp which was switched on only for the short periods of counting.

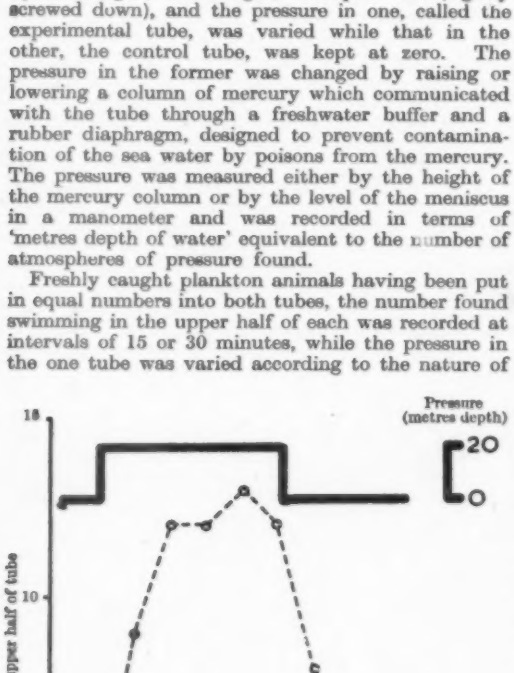

Fig. 1

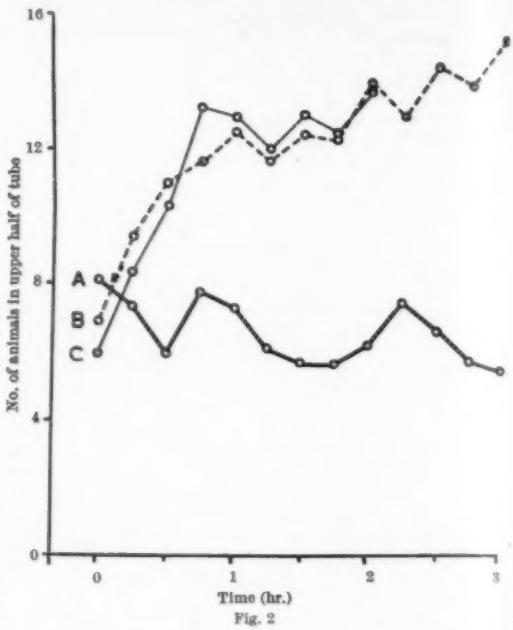

Fig. 2

While no effect of pressure on the behaviour of *Calanus* has been detected in any of many experiments so far performed, striking results have been obtained with mixed samples of Decapod larvæ which were almost entirely zœa and megalopa stages of *Portunus* and *Carcinus*. Fig. 1 shows in a graph the results of an experiment in which 25 larvæ were placed in each tube and the pressure in the experimental one raised to the equivalent of 20 metres depth and, after 2½ hours, reduced to zero again (as shown in heavy line at top of figure); the points connected by the continuous line *A* show the number of larvæ in the upper half of the control tube at half-hour intervals, and those connected by the broken line *B* show the corresponding numbers in the experimental tube. Very similar responses were obtained to increases of pressure equivalent to depths of 5, 10, 15 and 20 metres; it was also shown that a gradually increasing proportion of the total animals in the tube was found in the upper half while the pressure was maintained at a constant value for two or three hours. These two findings are illustrated in the graph in Fig. 2. Here the points connected by the thick continuous line *A* represent the average number of larvæ in the upper half of the control tube (pressure zero), at 15-minute intervals, in a large number of experiments in which 25 larvæ were placed in each tube. The points connected by the broken line *B* and by the thin continuous line *C* represent the average number of larvæ in the upper half of the experimental tube, in a similar number of such experiments, in which the pressure was raised just after the first observation was taken and maintained at the equivalent to 10 and 20 metres depth

respectively. In other experiments very similar curves were obtained for larvæ under pressures equivalent to 5 and 15 metres depth; but these are omitted so as not to confuse the figure.

Experiments investigating the effects of pressure on these and other plankton animals will be continued, and attempts will be made to discover some pressure-sensitive organ in animals so affected. It seems likely that some such receptor may exist, since response to both increase and decrease in pressure is so rapid, but such an organ does not yet appear to have been demonstrated in any invertebrate animal. It is improbable that the slight changes in the rates of some chemical reactions due to changes in pressure could be the mechanism employed, because the rates of such reactions are affected so much more by quite small changes of temperature.

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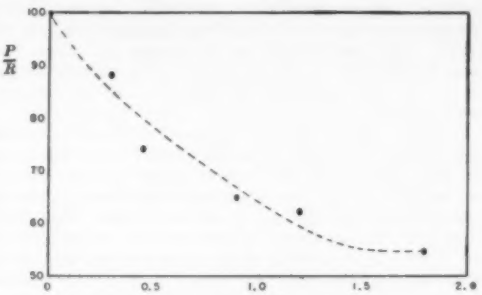
Effect of Bacterial Polysaccharide on Artificial Activation in the Frog Egg

The viscosity of dividing cells goes through definite changes, increasing during prophase, dropping abruptly at metaphase, and increasing sharply just prior to division[1]. These changes are believed essential for mitosis. Heilbrunn[2] has pointed out many similarities between the protoplasmic gelation which precedes the appearance of the mitotic spindle and blood clotting.

Frog eggs are activated most effectively by introducing a small amount of blood into the egg with a fine glass needle, and it has been suggested that this is due to clotting substances present in the blood which can induce this protoplasmic gelation[3]. In this connexion it is interesting that heparin inhibits, to some extent, the activating effect of blood[3,4], as well as cell division in tissue culture[5], and in fertilized *Chætopterus* eggs[6].

In the past few years, there has been great interest in the bacterial polysaccharide obtained by Shear *et al.* from *Serratia marcescens* as an agent which causes regression of tumours in mice[7,8]. It was hoped that this agent could be used in cancer therapy, but so far it has proved to be too toxic for widespread medical use. Heparin is a polysaccharide. Like heparin, the bacterial polysaccharide gives a metachromatic staining reaction with toluidine blue, it will inhibit cell division in the *Chætopterus* egg, and, as has been found in this laboratory by Mrs. Most, inhibits blood clotting[9]. It seemed of interest to inquire whether, like heparin, this bacterial polysaccharide could inhibit the activating effect on frog eggs of pricking in the presence of blood.

Rana pipiens females were induced to ovulate by injection of frog pituitary glands. Eggs were stripped in rows on to a glass slide, covered with the solution to be tested, and pricked with a fine glass needle. They were then placed in pond water which had been boiled, filtered and cooled. After four hours at room temperature, the percentage of dividing eggs was determined. No attempt was made to distinguish between normal and abnormal divisions. However, only those eggs which showed clear furrows were counted as dividing. Those showing only a wrinkling of the surface were not considered as dividing.



Polysaccharide in Ringer's solution (per cent)

Inhibition by polysaccharide of artificial activation.

$$P/R = \frac{\%\text{ cleavage in blood – polysaccharide solution}}{\%\text{ Cleavage in blood – Ringer's solution}} \times 100$$

The solutions tested were 1 : 1 mixtures of frog blood, obtained by heart puncture, and polysaccharide solutions of the following concentrations: 0·3, 0·45, 0·9, 1·2 and 1·8 gm. per cent. A 1 : 1 mixture of blood and Ringer's solution was used as a control solution. The polysaccharide was obtained through the kindness of Dr. Shear. In the accompanying graph, the ratio of the percentage of dividing eggs in the blood – polysaccharide mixture to that of dividing eggs in the blood – Ringer controls, multiplied by 100, is plotted against the concentration of polysaccharide used. These experiments show that the polysaccharide does indeed inhibit the activation of the eggs by pricking in the presence of blood.

This investigation was carried out with the aid of a grant from the U.S. Public Health Service administered by L. V. Heilbrunn.

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Oct. 20.

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Isolation of the Nitrifying Organisms from Soil

Nitrification of ammonium ions to nitrite and thence to nitrate is commonly a rapid process in soil; yet the isolation of the organisms responsible has always proved to be a difficult and tedious procedure. The reason for this is not difficult to find. The work of Winogradsky and of Meyerhof, which has been summarized in her book by the late Dr. Stephenson[1], has shown that the nitrifying organisms (*Nitrosomonas* and *Nitrobacter*) consume rather more than a hundred atoms of oxygen for every atom of carbon assimilated. On the other hand, the generality of (heterotrophic) soil organisms consumes only about five atoms of oxygen for every

atom of carbon assimilated, according to the results of experiments on the carbon dioxide outputs of soils[2]; this latter result of Porteous and Lees has been confirmed by as yet unpublished measurements of the oxygen uptakes of soils in the percolating respirometer[3].

It therefore seems likely that any attempt to isolate the nitrifiers by static liquid culture or by plating methods is foredoomed either to failure or to success tediously won. Under such conditions, where aeration is not very good, heterotrophic organisms with their low oxygen demand are almost certain to proliferate more rapidly than the nitrifiers with their high oxygen demand. Reference to Höber[4] suggests that if the nitrifiers are to grow at a reasonable rate in a static medium, say, at the rate of 1 mgm. dry-weight bacteria per 100 ml. medium per day, then the medium must be less than 1 mm. thick, otherwise the rate of oxygen diffusion into it will be insufficient. Moreover, since the production of 1 mgm. dry weight of the nitrifiers would consume all the oxygen in 250 ml. of air, only very limited growth of the nitrifiers can be expected in a Petri dish.

If, however, we ensure asepsis and adequate aeration of the medium by growing the nitrifiers in a soil percolator containing glass beads in place of soil and fed with sterilized air[5], conditions are made optimal for the nitrifiers, and consequently the statements[6] that "nitrifiers grow very slowly and any contaminants in enrichment cultures grow faster", and that "it is impossible to obtain pure cultures [of the nitrifiers] by simple serial transfers in liquid medium", which are true of static culture, are no longer necessarily valid.

I believe I have obtained the nitrifiers in pure culture by growing them in a soil percolator on a medium of the following composition:

$CaCO_3$	2 gm.
1 per cent NaH_2PO_4	1 ml.
Dialysed iron (B.P.)	5 drops
Molar $(NH_4)_2SO_4$	1 ml.
Distilled water to	100 ml.

The medium was initially inoculated with 1 gm. actively nitrifying soil. Subcultures were made by inoculating 1 ml. of the medium, in which nitrification had been established, into a fresh 100-ml. medium percolating over glass beads in a similar way. After five such subcultures, the nitrifiers were obtained in an apparently pure state. The criteria of purity were: (*a*) microscopical examination of the medium revealed only such colonies as were described by Meiklejohn[6]; (*b*) streaks on to nutrient agar showed no growth after three weeks; (*c*) the oxygen uptakes of the cultures, studied in the percolating respirometer[3], corresponded, within experimental error, to the amount of nitrogen oxidized by the cultures over a seven-day period.

It is hoped that this method of culture will provide nitrifying organisms in quantities sufficiently great to allow of a proper biochemical study of the organisms.

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Oct. 23.

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Influence of the Thyroid on Body Temperature of Growing Animals

The thyroid hormone, which regulates about 40 per cent of the body metabolism, is likely to influence the body temperature; but very little systematic work has been done to study the effects of the thyroid on the body-temperatures of growing animals. This seems to have some practical value, because the body-temperature gives an indication of the physiological state of the animal. In the present investigation the effects of known levels of thyroidal stimulation and inhibition, for short or long periods, on the rectal temperatures of the growing male rabbit and the ram have been studied.

Thyroidal stimulation within the physiological range did not affect the rectal temperature, whereas higher levels resulted in an increase in the rectal temperatures of the treated rabbits. The increase above the normal body temperature of the thyroxine-treated rabbit given such larger doses was relatively higher during the summer months than that observed during the winter months. Administration of moderate doses of thyroprotein did not affect the rectal temperature of the young ram. Continuous thiouracil feeding, or thyroidectomy, resulted in a significant decrease in the body temperatures of the young rabbit and the ram when compared with their respective controls. Simultaneous administration of thyroxine in amounts about equal to the estimated rate of secretion of thyroxine to the young thiouracil-treated rabbit maintained the rectal temperature to that of the control value.

It appears that there exists a relationship between the rise in the internal body-temperature and the dosage of thyroprotein administered in the young male rabbit. Detailed results will be described elsewhere.

I am grateful to Dr. J. Hammond and Dr. Arthur Walton for their help during the course of the present work, and to Mr. A. G. Carruthers for the statistical analysis of the results.

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Oct. 22.

Excretion of Œstrogens in the Urine of Non-Pregnant Ewes during the Breeding Season

Recent work[1,2] has demonstrated the presence of œstrogens in the urine of ewes during the last few weeks of pregnancy. It would appear that œstrogens have not been found in the excretions of non-pregnant ewes[3]. During the course of studies on reproduction in the ewe, attempts have been made at Ruakura to follow the œstrogen excretion of ewes over the œstrous, diœstrous and pregnancy periods.

With specially designed apparatus permitting the collection of twenty-four hour samples from grazing ewes at pasture[4], we have confirmed the findings of Whitten and Beck on the presence of œstrogens in the urine of pregnant ewes. In addition, we have been able to demonstrate œstrogen excretion in urine during the œstrous period. Using six mature Romney Marsh ewes and the bioassay technique of Evans *et al.*[5], mean uterine weights of as high as $18{\cdot}2 \pm 0{\cdot}92$ mgm. have been obtained from test mice, a result approximately equivalent to that obtained by the administration of 1·75 I.U. of œstrone. The mean

uterine weight for untreated controls was 7·8 ± 0·25 mgm. The chemical method of Pincus[6] for urine extraction, modified to avoid the toxic effects of *p*-cresol[7], was employed.

Studies are being continued to investigate as accurately as possible the œstrogen excretion-levels at different stages of the ewe's reproductive life.

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Hamilton, New Zealand. Sept. 25.

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Fruiting of the Oak Mildew

According to Butler and Jones[1], two reports only of the finding of cleistocarps of the oak mildew in Great Britain have been published, the first[2] referring to six cleistocarps on one leaf of *Q. robur* at Bricket Wood, Herts, in October 1945, the second[3] to "a few perithecia on leaves of *Quercus robur*" at Aberystwyth in October 1947. A third collection (Herb. I.M.I. 19315) identified by E. A. Ellis as *Microsphæra alphitoides* on *Q. robur*, from Wheatfen Broad, Surlingham, Norfolk, also in October 1947, is deposited at the Commonwealth Mycological Institute (information from S. J. Hughes).

Robertson and Macfarlane[2] directed attention to the dryness of the 1945 season in Hertfordshire, but also to recent records of cleistocarps from maritime countries (Norway and Holland). 1947 was an exceptionally dry season, and it is widely known that cleistocarps of the oak mildew were found in many parts of Great Britain. Around Bangor, in October 1947, they were found whenever searched for, and some coppice shoots and hedgerow oaks (*Q. petræa*) had cleistocarps on about one leaf in six.

During the more normal seasons of 1948 and 1949 no cleistocarps were seen in North Wales, despite the usual search; but in view of the fact that previous finds appear to have been restricted to dry seasons, it is worth recording the finding of a leaf of *Quercus petræa* bearing 43 cleistocarps in various stages of development at Church Island on the Menai Straits on October 12, 1950; that is, after an exceptionally wet season, in which the mildew mycelium was comparatively scarce, in one of the wetter districts of the British Isles, within about fifty yards of the sea (that is, the Straits).

Material has been deposited at Kew (Herb. I.M.I. 43967), and thanks are due to Mr. S. J. Hughes for comparing it with other material and confirming it as *M. alphitoides* Griffon and Maublanc, as provisionally identified by Robertson and Macfarlane[2].

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Bangor. Nov. 5.

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Studies on the Development of the Boll, and the Formation of Oil in the Developing Seed in some Varieties of Egyptian Cotton

The present work, concerning the development of the boll and the formation of oil, is an attempt to fill a gap in our knowledge of the botany of Egyptian cotton. Development of the boll was investigated in four varieties: Ashmouni, Sakel, Wafir and Maarad. Two of these, namely, Ashmouni and Maarad, were selected for the determination of the oil in the developing seed.

The first two weeks in the life of the boll were an 'intensive period' of development both in size and green weight. In this period alone, more than 80 per cent of size and green weight of the boll were formed in Ashmouni, Wafir and Maarad, and more than 70 per cent in Sakel.

During the third week, the rate of growth decreased rapidly until the boll reached its maximum size and green weight. The first three weeks may, therefore, be considered the 'productive period' of growth in the boll's life.

After this period, the weight and size of the bolls remained nearly constant for a period, then began to decrease very slightly shortly before opening; the latter decrease was most probably due to loss of water and shrinkage in the final stages of development.

The size of the boll of the four varieties was found to differ markedly: the biggest were Wafir and Maarad bolls, Ashmouni boll was intermediate, and the smallest was Sakel boll.

The number of seeds per locule and boll was determined, and it was found that the prevailing number of seeds per locule was 5–7 seeds, occasionally 4 or 8, rarely 3 or 9, and there was an indication that a positive relation exists between number of seeds and size of boll.

Formation of oil in the cotton seed did not show any relation to the growth of the boll (in size or green weight) or its contents. Most of the oil content of the seed was formed during a short and definite period of growth. This definite period of active oil formation started when the boll almost reached its maximum size and green weight, and continued for about twelve days, that is, from the twenty-first to the thirty-third day of the boll's age. Oil formation before and after this active period was very slow and insignificant.

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The Cellulosan of Jute Fibre

It has been shown[1] that a good-quality jute fibre contains about 28 per cent of hemicelluloses (that is, cellulosan and polyuronide hemicellulose of Norman[2]), of which, from furfural and carbon dioxide yield, 11·6 per cent was calculated to be xylan, 4·5 per cent polyuronides and the rest (by difference) hexosans. A 9·3 per cent caustic soda extract of the holocellulose (obtained from defatted jute with sodium chlorite[3]) at room temperature gives, on acidification and addition of an equal volume of alcohol, a white,

amorphous powder. This represents more than half the original hemicelluloses of the fibre, and consists of one molecule of mono-methoxyuronic acid linked with six anhydro-xylose units. On hydrolysis with dilute (up to 5 per cent) sulphuric acid, an aldobionic acid results, which, under more drastic conditions, splits up into xylose and methoxyuronic acid. The other portion, which remains dissolved in the 50 per cent alcohol, gives little furfural and practically no carbon dioxide, indicating thereby the absence of pentosans as well as polyuronides. Only galactose has so far been detected in it by hydrolysis and paper chromatography, and also by oxidation to mucic acid.

As alpha-cellulose from jute (prepared from chlorite holocellulose with 9·3 per cent caustic soda) contains no xylan[4], it appears that all the xylan of jute fibre occurs in combination with methoxyuronic acid and thus constitutes the encrusting hemicellulose of Norman[5], but no cellulosan. The furfural yield (more than 50 per cent) of this methoxyuronic acid–xylose complex satisfactorily accounts for that from the holocellulose. Since, according to Norman[6], cellulosan is predominantly a xylan, it would seem that either jute fibre contains no cellulosan, or it has a cellulosan which is free from xylan. A significant fact in this connexion is that a similar polyuronide hemicellulose can be isolated from jute cellulose prepared by the Cross and Bevan method, which is contradictory to Norman's classification[6].

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Histochemical Detection of Barium and Strontium

Small amounts of barium and strontium can be detected in the tissues of many insects by means of the extremely sensitive rhodizonate reaction. This reaction was described for microchemical use by Feigl[1], who has since investigated its limitations[2,3]. In the present histochemical method, tissues are fixed in carefully neutralized 10 per cent formalin in 70 per cent alcohol and immersed for 30–60 min. in a freshly prepared 1 or 2 per cent solution of sodium rhodizonate, in distilled water or in phosphate buffer at *p*H 7. Excess sodium rhodizonate is afterwards removed by washing in dilute alcohol. Stained tissues can be sectioned in the usual manner and permanent preparations obtained.

Both barium and strontium produce intensely coloured reddish compounds following this treatment. By means of chromate, barium can be distinguished from strontium. Unlike the corresponding strontium salts, barium chromate is less soluble than barium rhodizonate. Treatment with aqueous potassium chromate before staining with rhodizonate prevents the reaction with barium, and treatment after staining causes the red colour due to barium rhodizonate to be discharged. Spectrographic analyses have confirmed the presence of barium and strontium in the intensely staining tissues of several insects. Experiments with radioactive barium and strontium[4–8] provide confirmatory evidence that these elements are characteristically distributed in the insect body, as demonstrated by rhodizonate staining. Barium and strontium are absorbed in the midgut of most insects and deposited most frequently in the Malpighian tubules, less often in the midgut and reproductive organs, and only occasionally in the hindgut and fat body.

Both barium and strontium can be detected in bone. This is interesting in view of the recent report that both are indispensable for calcification in rats and guinea pigs[7]. The role of the deposits detected in insects, where calcification is usually unimportant, is at present unknown. One of their functions may be that of storage excretion.

Fuller details of the methods and results obtained will be published elsewhere[8].

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Carotenoids in the Heart Urchin, *Echinocardium cordatum*

Some specimens of the heart urchin, *Echinocardium cordatum*, which were kindly sent to us by Mr. J. R. Bruce (Marine Biological Station, Port Erin, Isle of Man), have been examined for carotenoids by the methods usually employed in this laboratory[1,2]. The gonads, which are almost colourless, yielded surprisingly large amounts of a carotenoid mixture which was resolved into three components: β-carotene, echinenone and lutein. β-Carotene and echinenone were the major components, lutein occurring only in traces. In the perivisceral fluid, on the other hand, echinenone and lutein occur in approximately equal amounts, while β-carotene is completely absent.

Echinenone, first isolated from the urchin *Paracentrotus lividus*[3], appears to be widely distributed in marine invertebrates, for apart from its presence in *Echinocardium cordatum*, noted here, it also occurs in the urchins *Echinus esculentus*[3] and *E. pictus*[4], in the gastropods *Patella vulgata* and *P. depressa*[3], and in the sponge *Hymenacidon sanguineum*[5]; further, it probably occurs in algæ, for evidence is available[6] that aphanin (from *Aphanizomenon flos-aquæ*)[7] and myxoxanthin (from *Oscillatoria rubescens*)[8] are identical with echinenone.

It is important to note here that the naphthaquinone pigments (echinochromes and spinochromes) which are widely distributed in sea urchins (see Goodwin and Srisukh[9] for a short review) are present in the test of *Echinocardium cordatum* only in traces and appear to be absent from the gonads.

Note added in proof. Dr. Lederer has recently pointed out to us that we[3] incorrectly stated that he

suggested 3-keto-β-carotene as the structure of echinenone. This was, in fact, Tischer's[7] suggestion for the structure of aphanin.

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Antigenic Variation in Certain Strains of *Bact. coli* Type I

The association of certain serological types of *Bact. coli* type I with infantile diarrhœa has been described by many investigators, particularly in Great Britain[1–4]. Identification of these strains has been based on the serological identification of the somatic *O*, the surface *K* and the flagellar *H* antigens[5,6]. Kauffmann subdivides the *K* antigens into three types, capsular *A*, thermolabile *L* and *B*; when heated, the *B* antigen retains its antibody-binding capacity, but loses its agglutinability.

The strains used in the following work were *D*.433 and *D*.437 isolated from two infants during an outbreak of neonatal diarrhœa at Derby, *D*.2101 and *C*.522 isolated from healthy babies in England, and *E*.1662 isolated by Dr. Neter in the United States from a baby with infantile diarrhœa. These five strains have identical somatic *O* and surface *B* antigens represented by the symbols *O*.111 (hundred and eleven) and *B*.4. Both on first isolation and in subsequent trials, it was found that these strains were non-motile when incubated at 37° C., irrespective of the type of medium used. By repeated subculture in nutrient broth and semi-solid agar and incubation at 22° C., highly motile cultures have been obtained. The period of passage required for this change has been three to four weeks in semi-solid agar and slightly longer in broth. Three have the flagellar antigen structure *H*.2; the flagellar structure of the two others has not yet been worked out. The somatic structure of these highly motile strains was reinvestigated, and it was found that the *B*.4 antigen could no longer be identified by agglutination, though the *O*.111 antigen gave similar serological results to the parent strain (see table). The doubling dilution method was used.

	Treatment	Agglutination		
		B	*O*	*H*
D.433 stock culture*	Nil	1 : 800	1 : 6,400	—
D.433 semi-solid agar	Passaged 6 months	—	1 : 12,800	50,000
D.437 stock culture	Nil	1 : 800	1 : 6,400	—
D.437 semi-solid agar	Passaged 2 months	—	1 : 3,200	50,000
D.2101 stock culture	Nil	1 : 800	1 : 6,400	—
D.2101 semi-solid agar	Passaged 4 months	—	1 : 12,800	— †
E.1662 stock culture	Nil	1 : 800	1 : 12,800	—
E.1662 semi-solid agar	Passaged 4 months	—	1 : 6,400	50,000
C.522 stock culture	Nil	1 : 800	1 : 6,400	—
C.522 semi-solid agar	Passaged 2 months	—	1 : 12,800	— †

—, no agglutination at 1 : 100.
*, stock cultures kept on Dorset egg without subculture.
†, *H* as yet unidentified but not *H*.2.

This loss of *B*.4 did not appear to be associated with any major smooth to rough change; but the point is being investigated. Before the loss of *B*.4 is complete there is an intermediate stage, when both the slide and tube agglutination give a muddy type of reaction which is very difficult to interpret. Cultures plated at this stage give colonies with differing degrees of agglutinability. At no stage in the passage have the biochemical reactions of these strains varied from those of the parent. This technique for causing the loss of surface antigen is being tested on other serological types of *Bact. coli*.

Stamp and Stone[7], investigating the surface antigen alpha which they identified on certain strains of *Bact. coli*, *Aerobacter* and *Proteus morgani*, found that this antigen was lost by repeated subculture of the non-lactose-fermenting strains, but that lactose-fermenting strains tended to retain the antigen during prolonged subculture. The strains of *Bact. coli* studied by us lost surface antigen *B*.4 on repeated subculture and incubation at 22° C. It appears that the loss of antigen *B*.4 is associated with the increase in motility. As yet, it has only been possible to prepare sera containing both *O* and *B* antibodies; but preliminary tests suggest that a serum containing only *B*.4 antibody may be prepared by the absorption of the *O* plus *B* antiserum with a suspension of the *O* variant described.

The identification of *B* antigen has been difficult with the usual *O* plus *B* antisera, and the use of pure *B* antiserum should help in the correct analysis of the antigenic structure of strains of *Bact. coli*.

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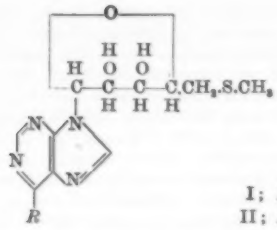
Structure and Synthesis of Adenine Thiomethyl Pentoside; Synthesis of 5′-Methylthio Inosine

Adenine thiomethyl pentoside is a sulphur-containing nucleoside first isolated from yeast[1]. On hydrolysis it yields adenine and a thio-pentose[2] which was thought to be a ketose bearing a methylthio or methoxy substituent[3] but later recognized as an aldose[4]. Periodate oxidation studies on the nucleoside, the thio-sugar, its osazone and the thio-pentitol obtained from it by reduction[5,6], indicated a 5-methylthio group, while the positive Böeseken test for *cis*-1 : 2 glycols favoured the ribose configuration. The osazone of the thio-sugar was identical with that of 5-methylthio-*d*-arabinose; but the two sugars themselves were not identical[6]. The nucleoside must then be a derivative of 5-methylthio-*d*-ribose, and spectroscopic evidence favoured N_9 for the position of attachment of sugar to purine[7]. The configuration about the glycosidic centre was unknown. On the basis of this evidence, formula (I) is considered probable for adenine thiomethyl pentoside.



I; $R = NH_2$
II; $R = OH$

This structure has now been fully established by a synthesis of 5′-methylthio inosine (II) from 2′ : 3′-*iso*propylidine-5′-*p*-toluene-sulphonyl inosine. When the latter compound[8] was heated with potassium mercaptide in dimethylformamide, 5′-methylthio-2′ : 3′-*iso*propylidine inosine (m.p. 234°) was obtained in good yield (found : C, 49·8; H, 5·4; N, 16·0; S, 9·3. $C_{14}H_{18}O_4N_4S$ requires C, 49·7; H, 5·3; N, 16·5; S, 9·5 per cent). The *iso*propylidine residue was removed by hydrolysis with *N* sulphuric in acetic acid at room temperature, giving 5′-methylthio inosine (II) (found : C, 44·3; H, 4·6; N, 18·5; S, 10·6. $C_{11}H_{14}O_4N_4S$ requires C, 44·3; H, 4·7; N, 18·8; S, 10·7 per cent).

The results of direct comparison of this synthetic substance with hypoxanthine thiomethyl pentoside, prepared by the action of nitrous acid on adenine thiomethyl pentoside[9], are given in the accompanying table.

	M.p.	Mixed m.p.	M.p. (Kofler block)	Mixed m.p. (Kofler block)	$[\alpha]_D^{20.1}$ in pyridine
Hypoxanthine thiomethyl pentoside	221–222°	221–222°	prisms 224° needles 227°	227°	−22·5° (±2°)
Synthetic	221–222°		prisms 223–224° needles 226·5°		−24·1° (±2°)

The sugars liberated on hydrolysis of both substances were indistinguishable on paper chromatography in butanol–water (R_F 0·65), as were the nucleosides (R_F 0·40) themselves and their purine components. Reduction of the thio sugar from the synthetic compound with sodium amalgam gave 5-methylthio-*d*-ribitol, fine needles (m.p. 118–119°, undepressed in admixture with an authentic specimen prepared from adenine thiomethyl pentoside[10]). Since 2′ : 3′ - *iso*propylidine - 5′ - *p* - toluenesulphonyl inosine was obtained from inosine, which in turn was prepared from adenosine, the structure of which is fully established[11], it follows that adenine thiomethyl pentoside is correctly described as 5′-methylthio-9-β-*d*-ribofuranosido adenine.

This conclusion has been fully confirmed by a synthesis of the latter from adenosine. From 4 gm. of 2′ : 3′-*iso*propylidine adenosine[12] by *p*-toluenesulphonation, reaction with potassium mercaptide in acetone–dioxan and removal of the *iso*propylidine residue with 0·5 *N* sulphuric acid in aqueous acetone at room temperature, 5′-methylthio adenosine (I) was obtained in small yield (70 mgm. after recrystallization twice from water) (found : C, 44·5; H, 5·1; N, 23·4; S, 10·7. $C_{11}H_{15}O_3N_5S$ requires C, 44·4; H, 5·1; N, 23·5; S, 10·8 per cent). It crystallized as long needles (m.p. 212–13°, undepressed when mixed with natural adenine thiomethyl pentoside, m.p. 213–14°). Both natural and synthetic substances showed the same R_F value (0·58 in butanol–water). The sugars liberated on acid hydrolysis were also indistinguishable (R_F, 0·65 in butanol–water).

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Rearrangement of the Amino-acid Residues in Peptides by the Action of Proteolytic Enzymes

Many studies of the structure of proteins are based on enzymatic hydrolysis. Since methods of determining the order of the amino-acids in a peptide chain have been developed[1], it is important to know whether the enzymatic hydrolysis gives products in which the sequence of the amino-acid residues is the same as in the parent protein. The possibility that enzymes bring about a rearrangement has been raised by Bergmann and Fraenkel-Conrat[2], who showed that transamidation occurred. Thus, by the action of papain, hippuric anilide was formed more rapidly from aniline and hippuric amide than from aniline and hippuric acid. Similarly, Fruton showed that, by transamidation, isotopically labelled ammonia was incorporated in certain amides in the presence of papain[3,4]. It has recently been found[5] that glutathione reacts with amino-acids to give their γ-glutamyl derivatives; this transpeptidation was brought about by an extract of sheep kidney.

We have now found that, in the degradation of certain tripeptides by a mixture of trypsin and chymotrypsin, the products include dipeptides in which the sequence of amino-acid residues differs from that in the original tripeptide. From the evidence collected by Neurath and Schwert[6], it seemed that L-lysyl-L-tyrosyl-L-lysine should be relatively resistant to direct hydrolysis by trypsin and chymotrypsin. We have synthesized this tripeptide, and examined by paper chromatography the nature of the products formed in its enzymatic degradation at *p*H 7·8 and 37° C. In addition to lysine, tyrosine, lysyltyrosine and tyrosyllysine, the dipeptide lysyllysine was formed. The lysyllysine was identified by comparison of its R_F values in several solvents with a synthetic sample; in addition, the sole product of its hydrolysis was lysine.

Lysyllysine could be obtained from lysyltyrosyllysine by a mechanism in which the hexapeptide

lysyl-tyrosyl-lysyl-lysyl-tyrosyl-lysine is formed as an intermediate which then breaks down to lysyltyrosine, lysyllysine and tyrosyllysine. The formation of such a hexapeptide is reasonable, since the central bond is of a type that is susceptible to tryptic cleavage, and so in the presence of trypsin there must be small amounts of the hexapeptide in equilibrium with the tripeptide. By the same reasoning, L-lysyl-L-tyrosyl-L-leucine should not form a hexapeptide intermediate. We therefore synthesized this tripeptide, and found that enzymatic degradation in this case also afforded lysyllysine.

If we assume that lysyllysine is obtained from both lysyltyrosyllysine and lysyltyrosylleucine by the same mechanism, the amide bond between lysine and tyrosine must be split by the α-amino-group either of lysine itself or a terminal lysyl residue. For example,

lysine + lysyl¦tyrosyllysine → lysyllysine + tyrosyllysine.

This is the kind of transpeptidation called 'carboxyl transfer' by Hanes[5]. The labile peptide bond seems susceptible of attack by anionoid reagents (cf. Fruton[3,4]). The alternative mode of transpeptidation ('amine transfer'), which has not been reported, seems less likely, at any rate in neutral solution.

Further work on the nature and specificity of these transpeptidation reactions is being carried out.

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Displacement Chromatography on Ion-Exchange Columns of the Carboxylic Acids in Plant Tissue Extracts

The importance of many carboxylic acids in metabolism makes it desirable that techniques for their estimation should, in general, be applicable to extracts of plant and animal tissues. It is essential that such extracts containing low concentrations of the significant acids should be as free as possible from inorganic salts, sugars and pigments. Such impurities, because of their relative abundance, can seriously detract from the value of paper chromatograms obtained using the technique of Lugg and Overell[1], which otherwise provides a rapid and convenient method of simultaneous separation and identification of carboxylic acids. Even the customary ether extraction of plant tissues does not always satisfy these purity requirements.

It has been found that a solution of the carboxylic acids contained in crude aqueous extracts of plant tissue can be obtained free from the impurities mentioned by means of displacement chromatography on the strong base anion exchange resin 'Amberlite *IR*A400'. The resin used was initially in the carbonate form, and the influent (crude aqueous tissue extracts or synthetic mixtures of the carboxylic acids) was allowed to flow slowly down the column at the rate of 1·0–1·5 ml. per min. No *p*H adjustment of the influent has been necessary, although Buck and Mottern[2] showed that for malic acid in apple juice, resin capacity varied inversely with the acidity of the influent. To handle the extracts studied in the present work, the most convenient column has been found to consist of 5 gm. (air-dry weight) of resin in a 0·80-cm. internal diameter glass tube. The volume of influent depends on the concentrations of the acids present; but we have found no trace of any acid in the percolate from 1 litre of influent containing up to 150 mgm. total of citric, malic and succinic acids passed through a 5-gm. column at a flow-rate of 2·0–2·5 ml. per min. Behaviour of the organic acids in either adsorption or elution was not altered by the presence of sugar at a concentration of fifty times that of the total amount of acids. Elution can be effected with 0·1 *N* or 1·0 *N* sodium carbonate or both, depending upon whether a preliminary separation is required before chromatography. It was found that malic and succinic were quantitatively eluted in the first 300 ml. by 0·1 *N* sodium carbonate; but citric acid was not observed until a further 300 ml. of effluent were collected.

As the preliminary separation by differential elution was not usually required, 250 ml. of 1·0 *N* sodium carbonate was used to elute all acids quantitatively from the resin. The elutant naturally contained a high concentration of sodium carbonate, which it has been possible to remove by the addition of the appropriate quantity of cation exchange resin 'Amberlite *IR*120' in the hydrogen form, or by electrolytic desalting. Desalting also removes the inorganic anions which were adsorbed from the crude extract and afterwards eluted simultaneously with the acids. If the eluate is not desalted, the cation resin used must be completely and thoroughly washed before use, otherwise residual free chlorides can give rise to 'comets' which tail off from the initial spot on the chromatogram. In many cases the use of ammonium carbonate as elutant has been found to be preferable, as then the excess elutant can be removed during concentration. Citric, malic and succinic acids are readily separated on paper chromatograms by a number of solvent systems[1], of which one of the best has been found to be mesityl oxide – formic acid. Although this solvent was reported[1] as undergoing condensation in the presence of formic acid, it has since been found that this effect is entirely absent with redistilled mesityl oxide[3]. Such a mobile phase moves much more rapidly than the customary *n*-butanol – formic acid system.

The method has been applied to aqueous extracts (made up to 250 ml.) of dried (80° C. for 48 hr.) apple (Statesman variety) and carrot tissues. The predominant acid in both extracts has been shown

(Mgm. acid per gm. Dry Weight of Tissue)

R (Mesityl oxide system)	*R*f (*n*-Butanol system)	Acid	Apple extracts			Carrot extract
			Outer	Middle	Inner	
0·31	0·30	*iso*-Citric	Trace	Trace	Trace	3·9
0·31	0·37	Citric	—	—	—	Trace
0·39	0·45	Malic	21·8	21·8	42·5	32·0
0·48	0·50	Unknown	—	—	—	Trace
0·54	0·55	Unknown	—	—	—	Trace
0·60	0·65	Unknown	Trace	Trace	Trace	1·8
0·70	0·74	Succinic	Trace	Trace	Trace	6·5
0·82	0·84	Fumaric	—	—	—	0·6

to be malic; but other spots were revealed on the chromatograms by spraying the sheets with a 0·04 per cent alcoholic solution of brom-cresol-green (*p*H 5·5). R_F values for the acid spots detected are given in the accompanying table. An interesting distribution of malic acid in the apple tissue was obtained by analysis of extracts of three 1-cm. thick shells of tissue cut from the outer, middle and innermost portions of the apple (see table).

Quantitative determinations of carboxylic acids have been made by comparing the masses of the paper containing spots of separated acids with reference curves obtained from the chromatograms of known concentrations of test acids (10–250 μgm. of each). Within this range, this method has been found to be accurate to ± 10 per cent about the mean. Electrometric titration of acids chromatographically washed from 'cuts' does not give consistently accurate results.

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Borides and Silicides of the Platinum Metals

Little attention has hitherto been given to the composition and structure of intermediate phases in the twelve binary systems comprising boron or silicon with ruthenium, rhodium, palladium, osmium, iridium or platinum. Each of the twelve systems has now been studied over the full range of composition, and the phases listed in the accompanying table have been characterized.

The boride and silicide phases were synthesized by heating weighed quantities of the pure elements, suitably mixed, in evacuated and sealed silica capsules, at 1,000–1,200° C.; in most cases the products were cooled slowly. X-ray powder photographs were taken (usually with unfiltered copper radiation) after opening the capsules and crushing the products. With a few metal-rich mixtures a malleable regulus was obtained; this was filed to a fine powder, and the powder annealed at a suitable temperature to eliminate mechanical strains.

The table shows the approximate stoichiometric composition of each phase identified; the composition-ranges over which the various phases are stable have not yet been determined precisely. Some uncertainty is attached to the stated compositions of silicon-rich, and particularly boron-rich, phases, on account of the low X-ray scattering powers of the non-metals, and the consequent difficulty in detecting them in mixtures with borides or silicides.

Many of the X-ray photographs reveal complex structures, but some of the simpler patterns have been successfully interpreted; in such cases provisional values for the lattice constants (in Siegbahn units) are shown in the table. Phases marked with an asterisk have not been reported previously. A few phases for which a stoichiometric composition could not be specified are marked in the table at the correct point in the sequence of compositions.

Metal	Boride phases	Silicide phases
Ruthenium	Ru_2B*	Ru_2Si*
	RuB*, cubic; *a*, 6·97 A.	RuSi*, cubic; *a*, 2·90 A. (CsCl structure)
	Ru_3B_2*	
	RuB_2*	RuSi, cubic; *a*, 4·70 A.
		Ru_2Si_3, tetragonal; *a*, 5·52, *c*, 4·46 A.
Rhodium	Rh_2B* (unidentified phase)	Unidentified phase
	RhB*	Rh_2Si*
	RhB_{2+}*	RhSi*
		Rh_2Si_3 or $RhSi_2$*
Palladium	Pd_3B_2 ?*, hexagonal; *a*, 6·48; *c*, 3·42 A.	Pd_2Si–PdSi, hexagonal: *a*, 6·52; *c*, 3·42 A. (for PdSi)
Osmium	OsB*, cubic; *a*, 7·03 A.	Os_2Si_3, tetragonal; *a*, 5·57; *c*, 4·47 A.
	OsB_2*	$OsSi_2$*
	OsB_{2+}*	
Iridium	Ir_2B_3*	Unidentified phase
	IrB*	Ir_2Si_3*, hexagonal; *a*, 3·96; *c*, 5·12 A.
	IrB_2*	IrSi*
		Ir_2Si_3*
		$IrSi_3$*
Platinum	Complex region	Unidentified phase
	Pt_2B_3 or PtB ?, tetragonal; *a*, 2·77; *c*, 2·95 A. (for PtB)	Pt_2Si or Pt_3Si_2 ?, tetragonal; *a*, 2·77; *c*, 2·95 A. (for Pt_2Si)
		Unidentified phase
		PtSi

Close similarity in the powder photographs suggests that the following pairs of phases are isostructural: RuB and OsB; Ru_2Si_3 and Os_2Si_3; RhB_{2+} and RhSi; Pd_2Si–PdSi and Pd_3B_2; IrB_2 and IrSi; Pt_2B_2 (?) and Pt_2Si_2 (?).

The two systems containing palladium are complex, and undoubtedly involve phases not yet identified.

Work is in progress on the phases not yet characterized crystallographically, and on the detailed structures of several of the simpler phases.

Several of the borides reported in the table have been prepared by an alternative method, namely, passage of hydrogen and boron tribromide vapour over the heated metal.

We acknowledge a generous loan of platinum metals from Johnson, Matthey and Co., Ltd. The X-ray equipment used was provided by a grant from the Royal Society. One of us (J. H. B.) has received a maintenance award from the Department of Scientific and Industrial Research.

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Binary and Ternary Catalytic Mechanisms in the Hydration of Acetaldehyde

In a recent paper[1], C. G. Swain has suggested that reactions which are catalysed by acids and bases normally take place by a ternary mechanism, in which the substrate is attacked simultaneously by an acid and a base. Such a mechanism accounts for the product term k' [HAc][Ac⁻] found by Dawson and Spivey[2] in the expression for the velocity of iodination of acetone in acetate buffers. It has commonly been held that the magnitude of this term was much too small to justify the assumption that the reaction goes primarily by a ternary mechanism involving water molecules[3]. However, Swain (*loc. cit.*) has shown clearly that this criticism of the ternary picture is not a valid one, since it ignores the experimental equivalence of pairs of kinetic terms such as [HAc][H_2O] and [Ac⁻][H_3O^+], or [Ac⁻][H_2O] and [HAc][OH^-]. Swain is, in fact, able to show that the

magnitude of the term k' [HAc][Ac$^-$] observed by Dawson and Spivey is close to that predicted by the ternary hypothesis on the basis of the other observed catalytic coefficients. Similarly, Swain shows that if the mutarotation of glucose also involves a ternary mechanism, the term in [HAc][Ac$^-$] will not contribute more than a few per cent of the total velocity, and would thus escape detection.

From the chemical point of view, the reversible hydration of acetaldehyde, $CH_3CHO + H_2O \rightleftharpoons CH_3CH(OH)_2$, is very similar to the mutarotation of glucose, since both reactions involve the reversible addition of a hydroxyl group to a carbonyl group. It has recently been shown[4,5] that this hydration reaction exhibits general catalysis by acids and by bases, and it turns out to be particularly suitable for testing the ternary hypothesis. The data of Bell and Darwent[5] show that the velocity of hydration (first-order constant, $\log_{10}$, min.$^{-1}$) in acetate buffers at 0° is represented by the equation :

$$k_1 = 4{\cdot}27 \times 10^{-2} + 3{\cdot}5 \times 10^{3}\,[H^+] + 2{\cdot}5 \times 10^{5}\,[OH^-] + 3{\cdot}20\,[HAc] + 0{\cdot}43\,[Ac^-]. \quad (1)$$

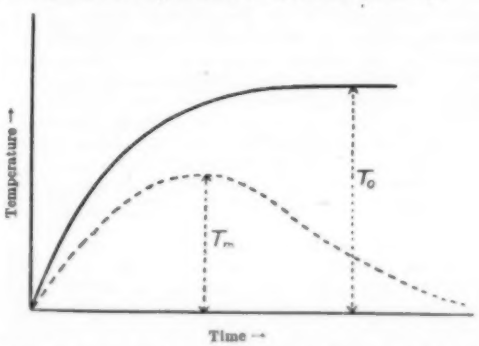
These experiments were done in very dilute buffer solutions, where it is unlikely that any term in [HAc][Ac$^-$] would be detectable, but it is easily shown that the ternary hypothesis predicts a large contribution from such a term in buffers of higher concentration. Following Swain's treatment, we can use the coefficients in (1) to write the velocity in the form :

$$k_1 = 1{\cdot}39 \times 10^{-5}\{[H_2O] + 5{\cdot}57 \times 10^{2}\,[Ac^-] + 3{\cdot}24 \times 10^{8}\,[OH^-]\}\{[H_2O] + 3{\cdot}35 \times 10^{3}\,[HAc] + 4{\cdot}54 \times 10^{8}\,[H^+]\}. \quad (2)$$

Remembering that $[H^+][Ac^-]/[HAc] = 1{\cdot}75 \times 10^{-5}$, $[H^+][OH^-] = 1{\cdot}14 \times 10^{-15}$, this is equivalent to :

$$k_1 = 4{\cdot}27 \times 10^{-2} + 3{\cdot}5 \times 10^{3}\,[H^+] + 2{\cdot}5 \times 10^{5}\,[OH^-] + 3{\cdot}20\,[HAc] + 0{\cdot}43\,[Ac^-] + 25{\cdot}9\,[HAc][Ac^-], \quad (3)$$

where the first five terms are identical with (1), and the last term increases in importance with increasing concentration ; for example, in a solution which is 0·1 *N* in acetic acid and acetate ions, it should contribute about 35 per cent of the total velocity.



We have carried out kinetic measurements to test these conclusions. At concentrations of interest, the reactions are so fast (half-time a few seconds) even at 0° that the dilatometric method previously employed cannot be used. For measuring reaction velocities in this range, we have developed a method which depends on observing small temperature changes caused by the heat of reaction. Its principle is illustrated in the accompanying diagram. The full curve represents the temperature change which takes place if the reaction occurs adiabatically, while the dotted curve applies to a well-stirred reaction vessel which is able to lose heat to the surrounding thermostat. The ratio T_m/T_0 will then depend on the relation between the rate of the reaction and the rate at which heat is lost by the system ; in particular, if the two rates can be represented by first-order constants k_1 and k_2, with $k_1/k_2 = R$, then it can be shown that

$$T_m/T_0 = R^{1/1-R}. \quad (4)$$

Since the maximum is a flat one, T_m can easily be determined without any measurements of time, and hence R calculated from equation (4). In the experiments reported here, the temperature changes (observed by using a thermistor or thermel) did not exceed 0·1°, so that the reaction conditions were effectively isothermal. The validity of equation (4) was tested by observing reactions with known kinetics, for example, the hydrolysis of ethyl glycollate by an excess of alkali, and the accuracy of the velocity constants is estimated at about 5 per cent. The details of the experimental method will be given in a later publication.

HYDRATION OF ACETALDEHYDE AT 0° C.

(First-order constants, $\log_{10}$, min.$^{-1}$)

[HAc]		0·025	0·050	0·045	0·100	0·084	0·200	0·300	0·500
[Ac$^-$]		0·025	0·050	0·015	0·100	0·420	0·200	0·300	0·250
k_1 (obs.)		0·22	0·32	0·52	0·55	0·52	0·91	1·28	1·93
k_1 (calc.)	(*a*)	0·25	0·34	0·53	0·52	0·52	0·91	1·28	2·03
	(*b*)	0·27	0·41	0·55	0·78	1·44	1·94	3·61	5·26

The results obtained are given in the accompanying table. The calculated velocities marked (*a*) are from equation (1), and those marked (*b*) from equation (2). It is clear that the data are well represented by (1), and that any term in [Ac$^-$][HAc], if present at all, must be much smaller than is predicted by Swain's treatment. It seems probable that the same conclusions apply to the mutarotation of glucose.

It must be concluded that it is unwise to assume either a binary or a ternary mechanism for acid-base catalysed reactions in general, and that each type of reaction must be investigated separately.

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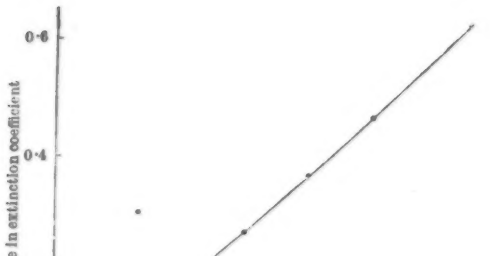
A Simplified Chemical Method of Radiation Dosimetry

IN 1949, Day and Stein[1] pointed out that doses of ionizing radiations of the order of 20,000 r. could be measured by estimating the phenols produced in dilute aqueous solutions of benzene. They estimated the phenols colorimetrically using the Folin–Ciocalteu reagent. In this method, the conditions under which the blue colour is developed must be carefully controlled, since its rate of production, maximum intensity and stability depend upon the freshness of the reagent and the *p*H and temperature of the solution.

An attempt has therefore been made to simplify the technique and eliminate the Folin–Ciocalteu reagent by estimating the phenol directly, using its



$\lambda = 2700$ A.; dose-rate = 540 r./min.

ultra-violet absorption at $\lambda = 2700$ A. At this wavelength, phenol absorbs about 330 times as strongly as benzene, so that it is possible to detect the production of quite small amounts (5×10^{-7} gm./c.c.). With a quarter-saturated solution of benzene water, the increase in extinction coefficient is about four-fold for a dose of 5,000 r. and about twenty-fold for a dose of 25,000 r. (see graph). In this dose-range, measurements can be reproduced within ± 3 per cent. The method is less sensitive than that employing the Folin–Ciocalteu reagent; but for doses greater than 5,000 r. it has been possible to obtain more consistent results with much less trouble.

I wish to thank Mr. J. St. L. Philpot for suggesting the principle of this method, and Dr. J. F. Loutit, director of this Unit, for his interest and encouragement.

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Changes of Crystal Structure in Antiferromagnetic Compounds

A recent communication by Selma Greenwald and J. S. Smart[1] has directed attention to the significance of the structural deformations observed by us in monoxides of the transition elements[2] in relation to their antiferromagnetic behaviour. It is particularly noteworthy that the temperatures at which departure from the high-symmetry face-centred cubic structure cell is first manifest are almost exactly the antiferromagnetic Curie temperatures. It would appear that deformations of the simpler arrangements existing above these Curie temperatures are a natural consequence of the setting of adjacent magnetic atoms in anti-parallel spin orientations below these temperatures. Neutron diffraction work on manganous oxide by Shull[3] has shown that the magnetic cell has a lattice constant double that of the elementary structure cell; but it remains for X-rays to demonstrate the change in shape consequent upon the preferential arrangement of the metal atoms.

Greenwald and Smart have determined, more exactly than we have done, the temperature at which tetragonal symmetry is assumed by cobalt monoxide. The temperature coincides with the antiferromagnetic Curie temperature. Moreover, they find that chromium sesquioxide, Cr_2O_3, which is an antiferromagnetic substance, exhibits anomalous changes in the structure cell dimensions, on cooling through the temperature at which large variations in magnetic susceptibility are found.

We can now add to the list the face-centred cubic form of manganous sulphide, MnS. Powder photographs with iron radiation of manganous sulphide at liquid-air temperature show splitting or multiplicity of such high-order reflexions as 420 and 422 but not of 400. A deformation of the face-centred cubic cell has therefore occurred on cooling, of the same kind as that found for nickelous oxide and manganous oxide—that is, such that rhombohedral symmetry is assumed. Departure from the cubic arrangement is appreciable at 95° K., and hence may well commence during cooling through the antiferromagnetic Curie temperature of 165° K.[4]; no deformation is noticeable at 200° K.

A further observation on ferrous oxide may also be reported. It is well known that the composition departs more or less from stoichiometric proportions according to the method of preparation, but is always deficient in iron with respect to FeO. We have found that the magnitude of the rhombohedral deformation from face-centred cubic symmetry is related to composition. At any given temperature, the deformation is greater for the least iron-deficient oxide than for an oxide of relatively low iron content. For example, we find that, at 95° K., the structure cell of the oxide most closely approaching FeO has a rhombohedral angle of 59° 32′, whereas for an oxide much more deficient in iron the rhombohedral angle is 59° 55′ (compared with 60° when there is no deformation from face-centred cubic symmetry).

Now, the concentration of iron atoms is greatest when the ferrous oxide is least iron-deficient. Consequently, at a given temperature, it might be expected that the influence of the exchange interactions on the effective potential energy of the magnetic atoms would be largest for the least iron-deficient oxide. It follows that, as the iron-deficiency increases, the antiferromagnetic Curie temperature should decrease, and the structural deformation at a given lower temperature should become less. In respect of the magnitude of structural deformation the expectations are confirmed by the above observations, and it would be interesting to have, as well, direct measurements of the antiferromagnetic Curie temperatures for ferrous oxides of different compositions.

It may be added that, although the structure cell decreases in size as the oxide becomes more iron-deficient, apparently such decrease by no means offsets the effect of the lower concentration of iron atoms.

Some evidence has been obtained that variations of a similar kind occur with manganous oxide.

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Half-lives of some Radioactive Isotopes

In the course of investigations with radioactive isotopes in this Department, anomalous rates of decay have been observed with some isotopes in particular chemical forms. The escape of iodine-131 from evaporated samples of sodium iodide has already been reported by one of us[1], and Hevesy[2] has reported the escape of carbon-14 from exposed samples of barium carbonate. Anomalies have also been observed in the decay of phosphorus-32 as disodium hydrogen phosphate in solution. In this case, the solution sometimes appears to form a mould (often very rapidly even in sterile solution) on to which the activity appears to concentrate. The activity of the solution over a period of time usually appears to decay more rapidly than the normal half-life of phosphorus-32 would indicate, although it does not appear to decrease regularly. Also phosphorus-32 incorporated as red phosphorus in polythene plastic, which has uses as a superficial applicator in radiotherapy, appears to exude phosphoric acid when prepared by calendering. Particularly in warm weather, apparent half-lives as short as eight days have been observed for phosphorus-32 in this form.

Measurements of the half-life of a number of isotopes in particular types of source in use in this Department were made to determine whether other anomalies existed. No further peculiarities were observed in the sources tested, but the values of the half-lives found for nine different isotopes may be of interest to others working in this field, particularly those of iridium-192 and tantalum-182.

Isotope	Source	Method of measurement	Period of observation	Half-life
*K-42	Solution K_2CO_3	Liquid counter	4 half-lives	12·5±0·2 hr.
*Na-24	Solution Na_2CO_3	,,	3·5 ,,	15·0±0·1 ,,
*Br-82	Solution $CaBr_2$	,,	5 ,,	35·7±0·3 ,,
Au-198	Gold colloid	,,	4 ,,	2·72±0·01 days
	Solid	β-Electroscope	3 ,,	2·74±0·015 ,,
†I-131	Solution NaI	Liquid counter	3 ,,	8·04±0·04 ,,
P-32	Solid Na_2HPO_4	β-Electroscope	3 ,,	14·60±0·05 ,,
	Solid Na_2HPO_4	,,	3 ,,	14·59±0·03 ,,
Ir-192	Solid Ir metal	γ-Ionization chamber	4 ,,	74·5 ±0·7 ,,
Ta-182	Solid Ta metal	,,	3·5 ,,	111 ±1 ,,
Co-60	Liquid $CoCl_2$	,,	1·7 years (0·32 half-life)	5·25±0·21 yr.

* Measurements also made with solid samples of the same chemical form with no apparent anomaly in the decay-rate.
† Reported previously (see ref. 1).

The values obtained for the nine isotopes investigated are listed in the accompanying table. In each case the type of source, method of measurement and period of observation are included. The measurements were made at intervals of about one-tenth of a half-life, and before each measurement the performance of the measuring equipment used was checked with standard cobalt-60 or radium-226 sources. The observation period extended over about three to five half-lives. It is quite difficult to extend this period if the constancy of the geometrical conditions of measurement is to be maintained. The values given in the table were calculated using the method of least squares, and the probable errors assigned to each value were calculated on the basis of this method[3]. It will be observed that in the case of gold-198 and phosphorus-32, the two values given for separate sources agree to within the limits of the errors assigned.

Most of the values given do not differ greatly from those in Seaborg and Perlman's table[4]. It will be noted, however, that a higher value (15·0 hr.) is found for the half-life of sodium-24, in agreement with a recent report by Solomon[5]. The value, 14·60 days, obtained for phosphorus-32 is significantly higher than the accepted value, 14·3 days, which is outside the range of error stated for these measurements. There was, however, no evidence of contamination with a longer-lived isotope (sulphur-35, for example), and further independent measurements of this important value are therefore desirable. An interim value for the half-life of cobalt-60 has been included, although the observation period is too short to obtain an accurate value.

We wish to acknowledge our indebtedness to Mr. A. Lee and Mr. Greenwood of this Hospital for their assistance in the calculations and assessment of errors; also to Prof. W. V. Mayneord for his interest and helpful criticism.

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Sigma-Phase in Transitional Metal Alloys

The existence of a phase isomorphous with the sigma-phase of the iron–chromium system has now been proved in a number of other alloys containing transitional elements. It has been observed in the following systems:

System	Observers
Iron-chromium	Cook and Jones (ref. 1).
Cobalt-chromium	Sully and Heal (ref. 2).
Iron-vanadium	Andrews (ref. 3); Wever and Jellinghaus (ref. 10).
Nickel-vanadium	Pietrokowsky and Duwez (ref. 4).
Cobalt-vanadium	Pearson, Christian and Hume-Rothery (ref. 5).
Chromium-manganese	Pearson, Christian and Hume-Rothery (ref. 5).
Vanadium-manganese	
Iron-molybdenum	Goldschmidt (ref. 6).

In the iron–chromium system this phase occurs at compositions close to the 50 : 50 atomic ratio. In some of the other systems, however, the range of homogeneity does not include the 50 : 50 ratio, and Sully and Heal[2] have already suggested that its occurrence may be determined by a critical electron : atom ratio, that is, that it is an 'electron compound'. Raynor and his co-workers[7] have shown that in the alloys of aluminium with transitional metals, phases of the composition X_2Al_9 (where X is one or more transitional elements) occur at an electron : atom ratio which varies from one alloy system to another in the range of 2·06–2·28. In calculating this ratio, the assumption is made that a proportion of the

valency electrons from aluminium is absorbed by the transitional elements to the full extent permitted by the vacancies in the 3*d*-levels of these elements, assuming Pauling's[8] values for the number of 3*d*-vacancies. It is also assumed that the electrons in Pauling's 'bond orbitals' (5·12 3*d*-electrons and 0·66 4*s*-electrons per atom of transitional metal) play no part in determining the electron : atom ratio.

It can be shown that the existence of the sigma-phase in alloys of transitional metals of the first long period with each other and with vanadium can be satisfactorily accounted for, and the composition at which the phase appears predicted, if, in the sigma-phase structure, it is assumed that electrons from the bond orbitals are absorbed to fill the vacancies in the 3*d*-atomic orbitals and that the structure is determined by a critical ratio of excess bonding electrons : atoms. For this purpose vanadium is regarded as having the same number of atomic orbitals (4·88 per atom) as the transition elements from chromium to nickel, and it is assumed that in the sigma-structure these are completely filled, although in elemental vanadium and in its alloys with non-transition metals these orbitals are empty. This critical ratio of excess bonding electrons to atoms is found to be 9 : 4 (2·25), which is close to the upper limit found by Raynor in the alloys of aluminium with the transition metals referred to above.

Using this ratio, the theory predicts the appearance of sigma-phase in the following systems, and the following values for the boundary of the sigma-phase field on the composition side, which is determined by an increase to values of the ratio greater than 2·25 by a decrease in the amount of the second constituent.

System	Predicted boundary (atomic %)	Observed boundary (atomic %)
Fe–Cr	43·5 Cr	43 Cr (ref. 1)
Co–Cr	62·3 Cr	56·6 Cr (ref. 9)
Ni–Cr	71·8 Cr	not observed
Fe–V	29·0 V	see below
Co–V	46·8 V	45 V (ref. 11)
Ni–V	57·4 V	55 V (ref. 5)

In most cases the agreement between predicted and observed values is satisfactory. In the iron–vanadium alloys the sigma-phase has been shown to occur[10] over a wide range of composition from approximately 30 to 60 atomic per cent vanadium. The range of homogeneity of the phase has not been determined. The predicted boundary must lie on the low vanadium side of the actual boundary, the actual error being unknown. It is of interest to note that, although the theory predicts the appearance of the sigma-phase in nickel–chromium, it has not been observed. It may be that the upper temperature limit for stability of the phase, which varies from system to system, is, for nickel–chromium, so low that transformation does not occur in a reasonable period of time.

It may also be noted that the range of composition for homogeneity of the sigma-phase in the systems in which it occurs can be accounted for fairly satisfactorily if it is assumed that the range of electron deficit which the structure can tolerate differs for each of the metals, chromium, vanadium and manganese, although relatively constant for each. The excess electron : atom ratio for elemental manganese lies within the permitted range of values, which perhaps accounts for the similarity noted by Bradley and Goldschmidt[12] between the structure of α-manganese and that of the sigma-phase.

The detailed electronic structure of elements of the second and higher long periods of elements is not sufficiently well known to enable similar predictions to be made about alloys containing these elements, but it is probable that the sigma-phase may be found in certain of these alloys. It is significant that, according to a recent communication[13], β-uranium is isomorphous with the sigma-phase.

A fuller account of this work is being prepared for publication elsewhere.

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Born and Green's Theory of Imperfect Gases

As is well known, the Born and Green theory of classical fluids[1] makes use of the so-called 'superposition-principle' first employed, in this connexion, by Kirkwood and Boggs[2]. Using this hypothesis, a non-linear integral equation is obtained for the radial distribution function, from which other properties of the fluid, such as its pressure, can be calculated.

In order to examine the validity of the superposition-principle at low values of the atomic density ρ, we have expanded the functions occurring in Born and Green's theory in powers of ρ, and so obtained a virial expansion for the pressure of the fluid (in this case, an imperfect gas). The expressions so obtained for the virial coefficients can then be compared with the true expressions given by the Mayer[3] theory of imperfect gases. If we write the virial expansion in the form

$$p = \rho kT\,(1 + B\rho + C\rho^2 + D\rho^3 + \ldots),$$

then we find that B and C are given correctly by the Born and Green theory, but that D is not. The true expression for D is given by

$$D = -\tfrac{1}{8}\iiint[\alpha_{12}\alpha_{23}\alpha_{31}\alpha_{41}\alpha_{42}\alpha_{43} + 6\alpha_{12}\alpha_{23}\alpha_{31}\alpha_{41}\alpha_{42} + 3\alpha_{12}\alpha_{23}\alpha_{34}\alpha_{41}]d\tau_2 d\tau_3 d\tau_4, \quad (1)$$

where $\alpha(r) = \exp[-\varphi(r)/kT] - 1$, $\alpha_{ij} = \alpha(|r_j - r_i|)$ and $\varphi(r)$ is the interatomic potential. Details of the calculation show that it is the first term in (1) that is not properly represented by the superposition-principle.

Moreover, if we first linearize the integral equation in the manner adopted by Rodriguez[4], we find that B and C are still given correctly, but that D is given by yet another expression, again not equal to (1).

When the atoms are represented by hard spheres of diameter a, it is possible to perform the calculations explicitly. As is well known:

$$B = b,\ C = \tfrac{5}{8}b^2, \text{ where } b = 2\pi a^3/3.$$

Born and Green's non-linear integral equation, embodying the superposition-principle, leads to $D = 0{\cdot}2252b^3$, while the linearized formulæ give $D = 0{\cdot}3958b^3$. These values may be compared with the value $D = 0{\cdot}2869b^3$ calculated from first principles by Happel and by Majumdar (see Fowler and Guggenheim[5]).

A fuller account of this work will be published elsewhere.

G. S. Rushbrooke
H. I. Scoins

Clarendon Laboratory,
Oxford.
Oct. 23.

[1] Born, M., and Green, H. S., "A General Kinetic Theory of Liquids", chapters 1 and 2 (Cambridge, 1949).
[2] Kirkwood, J. G., and Boggs, E. M., *J. Chem. Phys.*, **10**, 394 (1942).
[3] Mayer, J. E., *et al.*, *J. Chem. Phys.*, **5**, 67, 74; **6**, 87, 101 (1937).
[4] Rodriguez, A. E., *Proc. Roy. Soc.*, A, **196**, 73 (1949).
[5] Fowler, R. H., and Guggenheim, A. E., "Statistical Thermodynamics", 289 (Cambridge, 1939).

Simplified Calculation of a Linear Regression

The "simplified" method of calculating a linear regression put forward by Aldridge, Berry and Davies[1] is the well-known method of orthogonal polynomials which was put on a practical working basis by Fisher[2,3]. Unfortunately, in bringing this procedure again to the attention of research workers, the authors reproduce a misapprehension when they deduce that "whereas it is considered that four points are a minimum for determining the slope of the line, the number of observations should always be even", because observations at the centre point of an odd number of values of the independent variable contribute no information to the linear regression.

If it is known that the relationship is linear, then greatest accuracy for a given amount of labour will be achieved by concentrating all observations at the extremes of the practicable range—equal numbers at each extreme if the cost per observation is equal at all points. If it is required also to check the hypothesis that the regression is linear, then greatest efficiency is given by concentrating the observations at three points.

This may be most easily seen by considering the error variances for the linear and quadratic coefficients when observations are equally distributed between two, three or four points of the independent variable. (The quadratic coefficient is considered in this context only as a test for deviation from linearity.) To retain simple numbers let the extremes of the available range be at $x = -3$ and $+3$; and consider n observations distributed as follows:

x	-3	-1	0	1	3
(*a*)	$\frac{1}{2}n$	—	—	—	$\frac{1}{2}n$
(*b*)	$\frac{1}{3}n$	—	$\frac{1}{3}n$	—	$\frac{1}{3}n$
(*c*)	$\frac{1}{4}n$	$\frac{1}{4}n$	—	$\frac{1}{4}n$	$\frac{1}{4}n$

Let V be the variance of the dependent variate at any single value of x, and fit the orthogonal polynomial

$$y = A + B\,\xi_1 + C\,\xi_2;$$

where B is the usual linear regression, and C the quadratic coefficient. (With x symmetrically distributed and mean 0, $\xi_1 = x$, $\xi_2 = x^2$ — mean of x^2.)

Then the variance of B is $V/\Sigma\xi^2_1$, and of C is $V/\Sigma\xi^2_2$; and the values of the denominators, proportional to the amounts of information on each coefficient, for the above three cases are:

	$\Sigma\xi^2_1$	$\Sigma\xi^2_2$
(*a*)	$9n$	—
(*b*)	$6n$	$18n$
(*c*)	$5n$	$16n$

Thus, although the central observation contributes nothing to B, still the greater spread of two-thirds of the observations in distribution (*b*) gives 20 per cent more information than does distribution (*c*), while the concentration of the remaining third gives $12\frac{1}{2}$ per cent more information on the deviation from linearity.

The real choice is whether or not it is worth while to vary the proportion of observations in the centre class to gain greater accuracy on one coefficient at the expense of the other, but such variation will not usually be worth while. Greatest accuracy on C is given with distribution $\frac{1}{4}n$, $\frac{1}{4}n$, $\frac{1}{4}n$; but this will increase $\Sigma\xi^2_2$, in the units of the above table, only from $18n$ to $20{\cdot}25n$ at the expense of dropping $\Sigma\xi^2_1$ from $6n$ to $4{\cdot}5n$; on the other hand, if the central frequency be reduced below $\frac{1}{3}n$, the evaluation of curvature will be too inaccurate to be of much use as a critical test in cases of doubt, and one might as well 'plunge' for (*a*).

Yates[4] indicates some other points of view with respect to coefficients determined from three levels. An interesting study of efficient distribution of observations in regression analysis is given by Hotelling[5].

H. Fairfield Smith
Rubber Research Institute of Malaya,
Kuala Lumpur.
March 13, 1950.

[1] Aldridge, Berry and Davies, *Nature*, **164**, 925 (1949).
[2] Fisher, R. A., "Statistical Methods for Research Workers" (Oliver and Boyd).
[3] Fisher and Yates, "Statistical Tables for Biological Research" (Oliver and Boyd).
[4] Yates, F., Imp. Bur. Soil Sci. Tech. Comm. 35 (1937).
[5] Hotelling, H., *Ann. Math. Stat.*, **12**, 20 (1941).

The Permicron: a Unit of Wave Number

In spite of the great theoretical advantages of recording spectra in terms of frequency or wave number, most data on visible and ultra-violet spectra, more particularly spectra of solutions, are in practice expressed as wave-lengths with the millimicron as a favourite unit. One reason for this preference, apart from habit, is found in the inconvenience of sec.$^{-1}$ and cm.$^{-1}$ as units. Frequencies expressed in sec.$^{-1}$ involve large powers of ten ($\sim 10^{15}$), while the *fresnel*[1] ($= 10^{12}$ sec.$^{-1}$) has never become popular. Wave numbers in cm.$^{-1}$ are of the order of 10^4, and require the use of written or spoken powers of ten if the recorded values are to express the relatively low precision of measurement in spectra of solution. Thus, to say that the absorption maximum of bromine is at 405 mμ implies a reasonable uncertainty of about 10 A. in locating it. To express the value as 24,691 cm.$^{-1}$ or even as 24,700 cm.$^{-1}$ implies a much greater precision than is obtainable experimentally.

The difficulty could be overcome by employing a new unit of wave number, the number of waves *per micron*. This unit could be named 'permicron', and written as such or else as μ^{-1} or $/\mu$. Thus the precision of measuring the absorption maximum of

bromine is easily expressed by the significant figures in the value 2·47 permicron. Spectra in the visible, ultra-violet and nearer vacuum ultra-violet regions are in the range 1–10 permicron. The unit is easy to visualize, for example, with reference to colloidal dimensions. Its relations to important energy units are simple and easily remembered: 1 permicron = 1·24 eV. = 28·6 kcal./mole.

It is worth noting that although spectra recorded on a grating instrument are approximately linear on a wave-length scale, those recorded with prism instruments are much more nearly linear in wave number. Brode[1] has suggested 100 cm.$^{-1}$ as a unit of wave number, and has rather incongruously named it the 'cm.$^{-3}$'. It would seem that the permicron is preferable in both size and notation.

Noel S. Bayliss

Department of Chemistry,
University of Western Australia.
Nov. 3.

[1] Brode, W. R., in "Physical Methods in Chemical Analysis", 1 (edit. by W. G. Berl, Academic Press, New York, 1950).

Effect of Swine Influenza Virus on a Sulphonphthalein Dye

When swine influenza virus (Shope) is inoculated into the allantoic cavity of 11-day eggs simultaneously with a dye of the sulphonphthalein group (thymol blue, bromphenol blue, bromcresol green, bromcresol purple, bromthymol blue, phenol red, cresol red, 0·3 ml. of a 1 per thousand solution), it is found after forty-eight hours that a notable decrease in the colour intensity of the allantoic fluid has occurred as compared with that of the allantoic fluid of eggs inoculated with dye alone. We also found that this change in intensity was much less when the dye was inoculated together with human influenza *A*. For this experiment we used a *W.S.* strain, which for years had been cultivated on eggs in this Institute. This is also true of the swine influenza strain used for the first experiment. There was but little difference in the hæmagglutination titres of these strains. With this colour reaction it is possible to differentiate between the two strains. We are as yet unable to explain the cause of the change in colour intensity. A quantity of the dye is discoloured or removed from the allantoic fluid. There is no change in the *p*H of the allantoic fluid during the development of the virus.

H. Kunst

Virus Department,
Institute for Infectious Diseases,
University, Utrecht.
Oct. 3.

Synergistic Action of DDT and BHC Combined Sprays

DDT and BHC have so far been applied separately in malaria control programmes. In order to find out how these two insecticides will behave in a combined spray, experiments were carried out both in the laboratory and in the field. A combined spray containing 25 mgm. DDT and 5 mgm. (BHC) gamma isomer per square foot was compared with deposit of 50 mgm. of DDT or 10 mgm. of gamma isomer per sq. ft. applied separately. The results of tests carried out with houseflies and mosquitoes in the laboratory and in the field (in villages of the Gurgaon district, Punjab) have shown that in all cases the residual effect with suspensions was better than with emulsions or solutions, and that DDT–BHC in combination gave a longer residual effect (for two weeks or more) than DDT or BHC alone. The synergistic action of DDT and BHC in combined sprays was very obvious, as not only the combined sprays were effective for a longer period but were also more efficacious in keeping down the density of mosquito population in the villages.

Rajindar Pal

Malaria Institute of India,
Delhi.
Oct. 11.

The Term 'Eelworm-free Soil' in Plant Quarantine Regulations

International plant quarantine regulations now frequently require that imported plant material should be free from soil and should be accompanied by a certificate that the material was grown in soil free (*inter alia*) from the potato root eelworm, *Heterodera rostochiensis*, or possibly from other cyst-forming species of the same genus.

For the granting of such a certificate it is desirable to take a composite soil sample, mix it thoroughly, and recover any cysts contained in a weighed subsample. At present, a sub-sample of 200 gm. is frequently used. The numbers of cysts in unit weights of mixed soil are distributed in the Poisson distribution, from tables of which it can be found that a soil of mean content 0·7 cysts per 200 gm. will give a zero count in 50 per cent of cases, and one of 3 cysts per 200 gm. will give a zero count in 5 per cent of cases, assuming perfect recovery and recognition of cysts.

Cysts occasionally occur at depths of 24 in. or more, but most are to be found in the top 8 in. of soil. This depth of soil represents about 1 million kgm. per acre, so that there would be 5 million sub-samples of 200 gm. each per acre.

It would therefore follow that a certificate of freedom from eelworm cysts, based on such a method of sampling, need not mean what it states. With an eelworm cyst population of 3·5 million per acre in the top 8 in. of soil, there is an even chance of no cyst being present in a 200-gm. sample. With a population as high as 15 million per acre, no cyst will be present in such a sample in five cases out of 100. So that "No cysts found" really means, "It is very unlikely that there are more than 15 million cysts per acre". No harm is done provided that all concerned realize that this is the meaning of "eelworm-free soil".

Lest it be thought that such population-levels are trivial, and are made to seem imposing merely by using a per-acre basis, it should be added that at the 10-fold multiplication-rate per potato crop found by Oostenbrink in Holland[1], such infestations might be expected to give rise to symptoms of eelworm disease after two successive potato crops and to a crop failure after a third or fourth.

B. G. Peters

Rothamsted Experimental Station,
Harpenden, Herts.
Oct. 24.

[1] Oostenbrink, M., thesis, Wageningen (1950).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 5

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Annual General Meeting; Prof. J. H. Woodger: "Science without Properties".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "The Best Means of Explaining the Internal Operation of Electronic Valves".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (joint meeting with the LONDON SECTION, at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. W. B. Emery: "Properties, Production and Uses of Streptomycin".

PHARMACEUTICAL SOCIETY (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Dr. F. J. Dyer: "Biological Standardization—in Review and Pre-View".

Tuesday, March 6

INSTITUTE OF FUEL, NORTH-WESTERN SECTION (at the Engineers' Club, Albert Square, Manchester), at 10.30 a.m. and 2 p.m.—Conference on "A Study in Drying".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. E. H. Brown: "Oscillations in Sea-level and the Landscape".*

UNIVERSITY OF LONDON (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Prof. H. W. Turnbull, F.R.S.: "Group Representation and Invariant Matrices".* (Further lectures on March 7 and 8.)

INSTITUTE OF FUEL (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. W. Francis: "The Evaluation, Classification and Utilization of Coals from Commonwealth Sources".*

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. Glyn E. Daniel: "The Date of the European Megalithic Tombs" (Illustrated).

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL of the AGRICULTURE GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. R. W. Marsh: "Some Recent Developments in the Field of Agricultural Fungicides".*

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (joint meeting with the SCOTTISH BRANCH of the INSTITUTE OF PHYSICS, in the Natural Philosophy Department, The University, Glasgow), at 7 p.m.—Mr. D. T. N. Williamson: "High Fidelity Sound Reproduction". (To be repeated on Wednesday, March 7, at 7 p.m. in the Natural Philosophy Department, The University, Edinburgh.)

SHEFFIELD METALLURGICAL ASSOCIATION (at the Grand Hotel, Sheffield), at 7 p.m.—Prof. A. G. Quarrell: "Grain Refinement in Cast Alloys".

Wednesday, March 7

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. S. G. van Hoogstratton: "Diesel Engines for Oilfield Work".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. J. D. Holland: "Design Considerations for a Radiotelegraph Receiving System".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGICAL PANEL of the FOOD GROUP (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Dr. A. J. Kluyver: "Microbial Metabolism and its Industrial Implications".

INSTITUTE OF WELDING, MANCHESTER AND DISTRICT BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 7 p.m.—Mr. W. A. Wrate: "Principles, Design and Operation of Arc Welding Plant".

Thursday, March 8

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. E. Ashworth Underwood: "John Wesley and his 'Primitive Physick'."*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. R. A. Beatty: "Effects of Chloracetophenone and Di-*iso*propyl Fluorophosphonate on Amphibian Eggs"; Dr. C. G. Butler: "Observations on the Discovery of a New Source of Food by the Honey-bee (*Apis mellifera* L.)".

LINNEAN SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. G. Vandebroek: "The New Embryological Data and the Zoological Position of the Great Groups of Metazoa".

ASLIB (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. A. J. Wells: "How to Choose a Classification for your Special Library, or a Technique for Developing Present Schemes of Classification".

CHEMICAL SOCIETY (joint meeting with UNIVERSITY COLLEGE CARDIFF CHEMICAL SOCIETY, at University College, Cardiff), at 6 p.m.—Dr. H. W. Thompson, F.R.S.: "Some Aspects of Infra-Red Measurements in Chemistry".

LIVERPOOL METALLURGICAL SOCIETY (in the Lecture Theatre, Electricity Service Centre, Whitechapel, Liverpool), at 7 p.m.—Prof. H. O'Neill: "Atomic Structure and the Hardness of Metals".

WOOL EDUCATION SOCIETY (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7 p.m.—Dr. E. G. Carter: "The Scientist Looks at Wool".

Friday, March 9

BRITISH MYCOLOGICAL SOCIETY (in the rooms of the Linnean Society, Burlington House, Piccadilly, London, W.1), at 11 a.m.—Discussion on Mushrooms (to be opened by Mr. F. C. Atkins).

ASLIB, NORTHERN BRANCH (in the Lecture Room of the College of Technology and Commerce, The Newarke, Leicester), at 2.30 p.m.—Dr. Majorie Plant: "The Supply of Foreign Periodicals"; Mr. J. C. H. Hurd: "The History of the Knitting Machine Industry". (Leicester Conference.)

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (joint meeting with the INFRA RED DISCUSSION GROUP)—Infra Red Analysis Meeting.

At 2.30 p.m.: Visit to the Wool Industries Research Association at Torridon.

At 5.30 p.m.: Scientific Papers (in the Chemistry Department, The University, Leeds)—Dr. N. Sheppard: "The Scope of Infra Red Analysis"; Mr. H. A. Willis: "The Applications of Infra Red Spectroscopy to the Analysis of Polymer Compositions"; Dr. H. Powell: "Infra Red Spectrometry in the Petroleum Industry".

INSTITUTE OF FUEL (at the North British Hotel, Edinburgh), at 6 p.m.—Papers on "Drying of Animal By-Products".*

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Prof. J. W. Bonebakker: "The Application of Statistical Methods to the Analysis of Service Performance Data".

OIL AND COLOUR CHEMISTS' ASSOCIATION, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Dr. R. B. Waters and Mr. E. B. Robinson: "Urethane Oils".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. L. R. G. Treloar: "Rubber—a Remarkable Material".

Saturday, March 10

CHEMICAL SOCIETY (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, in the Washington Singer Laboratories, Prince of Wales Road, Exeter), at 2.15 p.m.—Discussion on Training of Scientists.

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (at the University, Liverpool), at 2.30 p.m.—Mr. W. L. Howe and Mr. A. M. Moult: "The Reactivation of Bone Charcoal".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF EDUCATION, with special qualifications in Chemistry—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (March 10).

ASSISTANT DIRECTOR OF RESEARCH IN ECONOMICS—The Secretary, Faculty of Economics and Politics, Marshall Library, Downing Street, Cambridge (March 14).

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics and some knowledge of electro-acoustics and electronics with experience in the planning of research) at the Royal Air Force Acoustics Laboratory in London, under the Air Ministry—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 4002/51 (March 14).

BIOCHEMIST (Grade III), A.C.T. Nutrition Research Laboratory and Museum Section, Canberra—The Chief Medical Officer, Australia House, Strand, London, W.C.2 (March 15).

LECTURER IN MATHEMATICS (Pure)—The Secretary, Queen's University, Belfast (March 15).

LECTURER or SENIOR LECTURER IN ZOOLOGY—The Secretary of University Court, The University, Glasgow (March 15).

SENIOR LECTURER IN THE DEPARTMENT OF TOWN AND COUNTRY PLANNING, University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 16).

CHEMISTS (Experimental Officer grade) in Ministry of Supply research and development establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.704/50A (March 17).

CHEMISTS and CHEMICAL ENGINEERS (Scientific Officer grade) in Ministry of Supply experimental establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.726/50A (March 17).

CHIEF OF THE DIVISION OF PLANT INDUSTRY, Commonwealth Scientific and Industrial Research Organization, Canberra—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3287 (March 17).

LECTURERS and ASSISTANT LECTURERS IN BOTANY, CHEMISTRY, ZOOLOGY, PHYSICS and ZOOLOGY, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 17).

ROBERT BLAIR FELLOWSHIP IN APPLIED SCIENCE AND TECHNOLOGY tenable in the Dominions, the United States or other foreign countries—The Education Officer (H1/2), The County Hall, London, S.E.1 (March 17).

SENIOR LECTURERS IN BOTANY, CHEMISTRY, GEOLOGY, PHYSICS and ZOOLOGY, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 17).

READERSHIP IN GEOGRAPHY at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 19).

ASSISTANT KEEPER, Grade I (Deputy Director), and an ASSISTANT KEEPER, Grade II (for the Library), at the National Maritime Museum, Greenwich—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4005/51 (March 20).

DEPUTY (Deputy Chief Scientific Officer grade) TO THE SCIENTIFIC ADVISER to the Air Ministry—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4008/51 (March 21).

READERSHIP IN BOTANY at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 22).

RESEARCH ASSISTANT (with a general knowledge of maritime history and art, including the historical side of naval architecture) in the National Maritime Museum, Greenwich—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4004/51 (March 22).

BIOCHEMIST (with an honours degree in chemistry, or equivalent, and wide experience of analytical chemistry or hospital biochemistry) to work under the direction of the Pathologist—The Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2 (March 26).

CHEMISTS (Senior Scientific Officer grade) at Ministry of Supply headquarters in London—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4007/51 (March 29).

ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, The University, Manchester 13 (March 30).

ASSISTANT LECTURERS (2) IN GEOGRAPHY, ASSISTANT LECTURERS (3) IN PHYSICS, ASSISTANT LECTURERS (2) IN CHEMISTRY, ASSISTANT LECTURERS (2) IN BIOLOGY, ASSISTANT LECTURERS (2) IN GEOLOGY, ASSISTANT LECTURERS (3) IN EDUCATION, and a LECTURER IN MATHEMATICS—The Registrar, University College of North Staffordshire, Keele, Stoke-on-Trent (March 31).

LECTURER or a SENIOR LECTURER IN PHARMACOLOGY—The Registrar, The University, Leeds 2 (March 31).

STUDENTSHIPS IN PLANT BREEDING, ENTOMOLOGY, PLANT PATHOLOGY and SOIL SCIENCE—The Secretary, Empire Cotton Growing Corporation, 12 Chantrey House, Eccleston Street, London, S.W.1 (March 31).

WARDEN or ASSISTANT WARDEN of a men's hall of residence (the candidate appointed will be required to undertake lecture or tutorial work in one of the subjects taught at the College)—The Registrar, University College of North Staffordshire, Keele, Stoke-on-Trent (March 31).

EMSLIE HORNIMAN ANTHROPOLOGICAL STUDENTSHIPS—The Secretary to the Trustees, Emslie Horniman Anthropological Scholarship Fund, Royal Anthropological Institute, 21 Bedford Square, London, W.C.1 (April 1).

LEON FELLOWSHIP FOR RESEARCH (preferably in the fields of Economics or Education)—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 1).

RESEARCH FELLOWSHIP IN ECONOMIC STATISTICS—The Registrar, The University, Manchester 13 (April 1).

PROFESSOR OF BOTANY at Rhodes University College, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 15).

DEWAR RESEARCH FELLOWSHIP—The Secretary, The University, Edinburgh (April 30).

SENIOR LECTURER IN MINING ENGINEERING at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

ASSISTANT LECTURER IN THE DEPARTMENT OF APPLIED MATHEMATICS—The Registrar, The University, Liverpool (May 1).

PROFESSOR OF MINING at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 31).

LABORATORY MANAGER (Ref. MA./6) to take charge of metallurgical investigations connected with the development of atomic energy production processes, a PRINCIPAL PHYSICIST (Ref. ME.1/1) to take charge of a laboratory applying physical methods to metallurgical investigations, including the design and development of measuring instruments, and a PHYSICAL METALLURGIST (Ref. ME.1/20) to take charge of metallographic laboratories engaged on investigations essential to the development of atomic energy production processes, in the Department of Metallurgy, Risley—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

LABORATORY TECHNICIAN to work in new biochemical research laboratory—The House Governor, The Royal Cancer Hospital, Fulham Road, London, S.W.2.

PHYSICAL CHEMIST (with an honours B.Sc., and some experience in spectrography and other physical aspects of chemical analysis), as Assistant in Research Department—The Director of Research, Glasgow Royal Cancer Hospital, 132 Hill Street, Glasgow, C.3.

QUALIFIED ZOOLOGIST to undertake research work in entomology—The Secretary, Department of Entomology and Parasitology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool 3.

RESEARCH OFFICER (Ref. A.4) (with degree in physics or equivalent) for work on full- or semi-scale plant, eventually to supervise technical investigations on dust and pulverizing, a RESEARCH OFFICER (Ref. A.5) with degree in physics, or equivalent, a RESEARCH OFFICER (Ref. A.6) (with honours degree in chemistry) to undertake work on the behaviour of coals during utilization in relation to their structure and constitution and a RESEARCH OFFICER (Ref. A.7) (with honours degree in chemistry or physics) for field work in addition to laboratory duties—The Assistant Secretary, British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey, quoting the appropriate Ref. No.

REPORTS and other PUBLICATIONS

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